STRATEGY TO REDUCE OIL DEPENDENCY AND ESTIMATION OF INDONESIA'S ENERGY DEMAND IN 2030

Submitted by:

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Concentration: Sustainable Development Management

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STATEMENT OF PRINCIPLES

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I hereby certify that the dissertation that I was submitted as a part fulfillment of requirements for the degree of Doctor of Economics at Trisakti University is the result of my own work.

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Jakarta - August 17th, 2014

Dwi Atty Mardiana

ABSTRACT

Indonesia's oil consumption increases twice as fast as the world's while the domestic production is declining, causing steady growing dependency on imported oil, economic balance of payments deficit, high subsidy cost, and negative effect towards national energy security.

The objective of this paper is to examine the factors that influence and determine oil import in Indonesia, makes projection of energy needs from 2012 to 2030, and simulates various alternative strategies to deal with oil dependency. The simulation is run to see the effects of: (a) economic growth, (b) domestic gasoline price, (c) international oil price, (d) incremental oil production, (e) refinery efficiency, and (f) energy diversification on the increase in energy and oil import requirement.

The analysis uses the energy model which is estimated by two-stage least square (2SLS) framework. The validation of the data from 1990 to 2011 had been done before forecasting and simulating the model by changing the value of exogenous variables. Indonesia's energy model is constructed by modifying IEA's world energy model by including non-fossil energy into the model that reconciles the flow of energy supply, transformation, and the final demand which is disaggregated per sector of energy user and type of energy.

The investigation on the relationship among GDP, world oil price, domestic oil price, oil production, refinery efficiency, energy diversification, and oil import requirement shows that the increasing world oil price will not affect oil import through its consumption due to oil subsidy; while other variables will affect it significantly. The forecast shows that Indonesia's oil import will be more affected by the consumption of transportation fuel rather than economic growth and it is estimated that Indonesia will become a net energy importer in 2015. Converting gasoline to gas in transportation sector, diversifying fossil fuel to geothermal for electricity and reducing domestic oil subsidy can help reducing the tendency to import energy and increasing energy security; but the impact of higher oil production and refinery capacity is relatively small.

This paper suggests that sustainable energy security in Indonesia can be achieved by focusing early on the optimization of various energy resources which have already existed to support the energy consumption growth, while the oil production will be fully exhausted in the next decade.

Keywords: 2SLS, energy diversification, energy projection, oil subsidy, oil import, balance of payment, energy model, energy security

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With my background in oil and gas industry, I desire to get better understanding on the contribution of oil and gas as a non-renewable energy for the future energy security and national economic sustainability.

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Cibubur - August 17th, 2014
Dwi Atty Mardiana

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CHAPTER I

INTRODUCTION

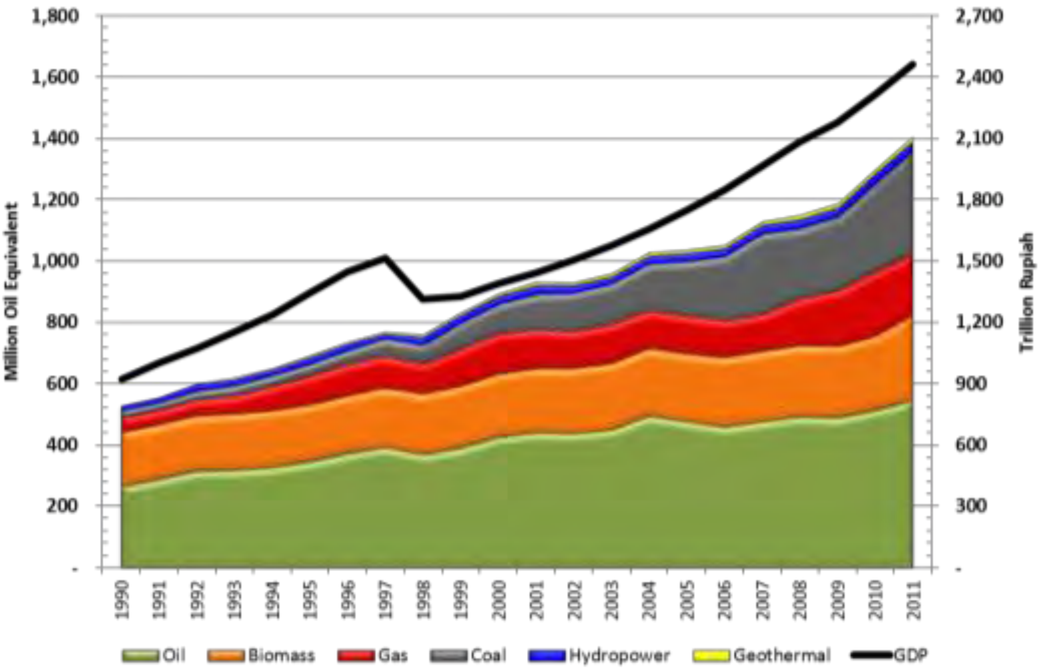
1.1 Background

The availability of energy in sufficient quantities and continuous is very important to drive a nation's economic activity (Belke *et al.*, 2011; Francis *et al.*, 2010; Squalli, 2007). BP Statistical Review (2013) and IEA (2010) estimated that in 2035, energy demands in developing countries outside the Organisation for Economic Co-operation and Development (OECD) will increase by 1.6 times over the OECD members' due to the rapid industrial growth and the expanding population.

The increase of energy consumption will encourage competition among countries to access energy resources and raise concerns on future energy security to be obtained at reasonable price. In addition, environmental degradation is an inevitable result of the inexorable increase in energy consumption (Hameed, 2011; IEA, 2010; Jalil and Mahmud, 2009; Apergis and Payne, 2009), and environmental problems will stunt the economic development planning process (Fong *et al.*, 2007). In Malaysia, the National Green Technology policy was introduced in order to reduce the rate of energy consumption and simultaneously enhance economic development (Islam *et al.*, 2009).

Indonesia is a developing country with economic growth of 6-7 percent and a population of almost 250 million people, making it one of the strong economic potential countries in Asia (IMF, 2013) and requiring a lot of energy to support its economic growth (BPPT, 2013; MoEMR, 2010b; BP Statistical Review, 2013; IEA, 2010). Energy has a vital role in Indonesia's economic development, not only as a source of the state's revenue, but also as a catalyst of its economic growth (MoEMR, 2012; BPMIGAS, 2010).

Chart 1.1 Energy Consumption and GDP of the period from 1990 to 2011



Source: MoEMR, 2013 (processed)

Chart 1.1 shows Indonesia's total energy consumption by type of energy and its Gross Domestic Product (GDP) at constant 2000 price from 1990 to 2011. On average, in the last 5 years, energy consumption grew at 6.1 percent per year, higher than GDP growth at annual rate of 5.9 percent. This relationship is a characteristic of a rapidly developing economy (Adams and Chen, 1996; Zilberfarb and Adams, 1981) which is reflected by increasing industrialization, technology, and living standards (Medlock, 2009).

Nevertheless, Indonesia's energy condition today is facing many problems. Starting with the paradigm that Indonesia has large oil reserves and other energy resources, then the society deserves energy retain at low price. The government that is encouraged by the important role of energy then feels the need to intervene energy pricing process while ensuring its availability in domestic market through fuel subsidy.

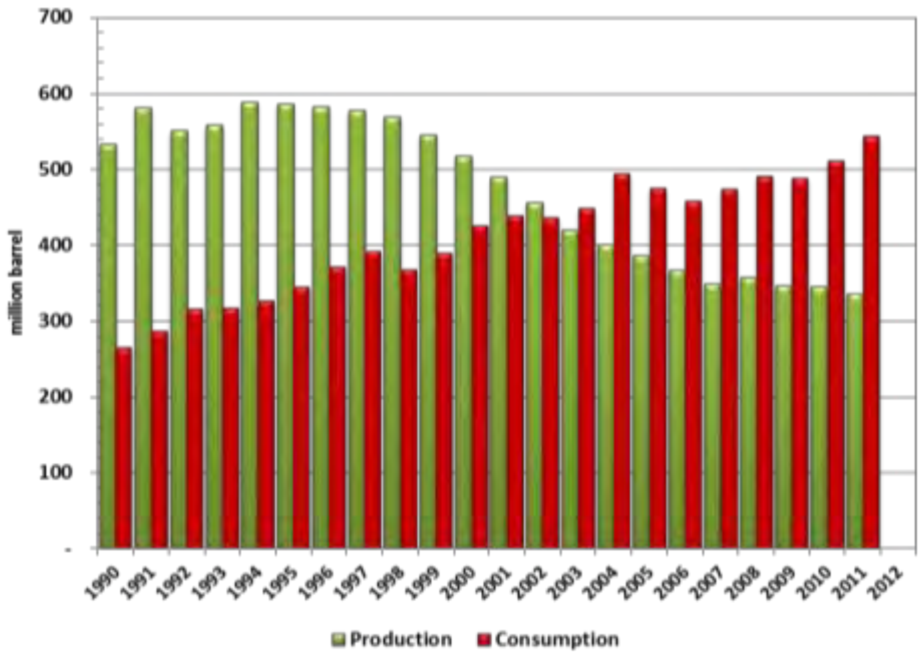
Fuel subsidy is given to some particular types of fuel to reduce fuel prices so they can be affordable by the society while price stability is being maintained. Hence, there are two existing fuel prices in Indonesia, i.e. subsidized and non-subsidized prices. Subsidized fuel prices are prices regulated by the government after considering the provision cost of certain types of fuel supplied by Pertamina and the society's capacity level, so the difference between the international oil import prices and the subsidized local fuel will be borne by the government through subsidies. In the other hand, the non-subsidized fuel prices are the prices of some particular types of fuel based on the fluctuations in international oil prices after being added by production costs and profits.

Unfortunately, the implementation of this price policy leads to economic problems, such as: (a) misdirected subsidies (General Directorat of Oil and Gas, 2012; IEE, 2009; Ermawati and Jusmaliani, 2008), (b) inefficient energy use (LPEM-FEUI *et al.*, 2012; CSIS, 2011; Matheny, 2010), (c) the utilization of other energy sources has not been optimized due to its high production cost and worsen by the subsidy policy on oil fuel, (d) burned government budget due to high subsidy cost, (e) reduced fiscal space, meaning the government has fewer resources to promote growth through investments in infrastructure or human capital, (f) the deficit balance of trade as the cost of oil import is higher than the export, (g) reduced foreign exchange reserves for imports and foreign debts, and (h) generated corruption and smuggling opportunities when products bought domestically below market prices are smuggled to neighboring countries or being used for unintended purposes, such as mixing the subsidized and household fuel with other fuel types and using the doctored fuel for industrial purpose (Active Program, 2013).

Another energy problem is from the supply side, which is the limited investment and technology in: (a) upstream oil and gas activities, such as exploration and exploitation, (b) oil refineries construction in downstream industry, and (c) development of new and renewable energy, also the limited energy infrastructure in rural and remote areas restricting public access to meet its energy needs.

Chart 1.1 shows that oil still dominates Indonesia's energy use by 39 percent in 2011 (544 MBOE of total 1400 MBOE) and continues to increase that it doubles oil use in 1990 which is amounted to 256 MBOE. The rise of oil demand exceeds its supply, encouraging imports in order to meet the energy needs. Higher oil imports than the exports has made Indonesia a net oil importer since 2004 and left the Organization of Petroleum Exporting Countries (OPEC) membership in 2008 after joining in 1962. Chart 1.2 shows the gap between oil consumption and production that had been increasing since 2004. In the last decade, oil production of the country decreased steadily caused by disappointing exploration efforts and declining production of oil in the existing oil fields (E.I. Administration, 2007).

Chart 1.2 Oil Production and Consumption of the period from 1990 to 2011

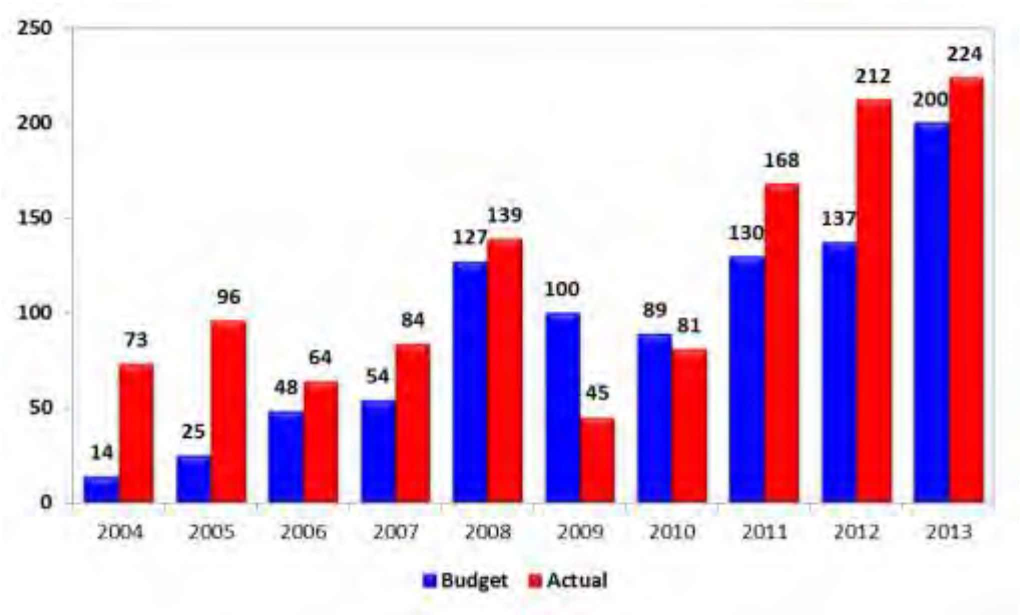


Source: MoEMR, 2013 (processed)

According to Handbook of Energy by MoEMR (2013), to meet domestic oil demand amounted to 439 MBOE in 2011 or equivalent to 1.2 MBOE per day, Indonesia has to import 555 thousand BOE of petroleum product per day and 265 thousand BOE of crude oil due to limited refinery capacity and declining domestic crude oil production (649 thousand BOEPD or 918 thousand BOEPD before export). Thus, 59 percent of Indonesia's oil demand or 19 percent of Indonesia's energy requirement is obtained through imports.

As a net oil importer, the increase of oil consumption and international oil price will affect the balance of trade, burden the currency depreciation (Restyani, 2012; Resosudarmo, 2002; Mishkin, 2001; Said *et al.*, 2001), causing higher cost of imports and lower value of exports, resulting the decrease of real national income (Sukirno, 2011; Surjadi, 2006). The high cost of subsidy will burden the state budget (Sawitri, 2006), exacerbating fiscal balance (CSIS, 2011) and restricting the state budget for physical infrastructure development.

Chart 1.3 Actual Oil Subsidy of the period from 2004 to 2013 (in trillion rupiah)



Source: Budgetary Council, depkeu.go.id (processed)

Chart 1.4 and Table 1.1 shows oil and gas' trade deficit as of September 2013, as a result of the high oil and gas imports amounted to 33.4 billion USD and push the trade deficit by 6.3 billion USD that hinders economic growth in 2013 to below 6 percent.

The high dependence on petroleum and the negative impacts on the economy raise concerns about Indonesia's energy security sustainability and its economy in the future. Therefore, researcher suggests a research titled "Strategy to Reduce Oil Dependency and Estimation of Indonesia's Energy Demand in 2030".

Chart 1.4 Oil and Gas Balance of Trade (in billion US$)

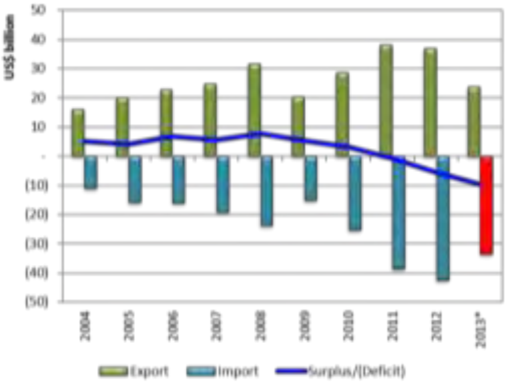


Table 1.1 Goods and Services Balance of Trade (in billion US$)

Description	Billion (US$)			
	2010	2011	2012	2013*
Total Export	158,3	200,1	190,1	134,0
Non oil and gas	129,7	162,0	153,1	110,2
Oil and gas	28,6	38,1	37,0	23,8
Total Import	133,6	175,4	191,7	140,3
Non oil and gas	108,2	136,7	149,1	106,7
Oil and gas	25,4	38,7	42,6	33,6
Surplus/(Deficit)	24,7	24,7	(1,6)	(6,3)
Non oil and gas	21,5	25,3	4,0	3,5
Oil and gas	3,2	(0,6)	(5,6)	(9,7)

*) September 2013
Source: BI (www.bi.go.id)

Since the first oil shock in the early 1970s, there has been a significant increase in the number of research studies of energy demand in order to determine the economic policy (Hotunluoglu *et al.*, 2011; Miskinis, 2002), reduce dependence on energy imports (Ghosh, 2009; Zhao *et al.*, 2007; Adams *et al.*, 2000), increase national energy security (Dilaver, 2012; Agrawal, 2012; Zhou, 2012; Adams *et al.*, 2007; Ito *et al.*, 2006), and protect environmental sustainability (Inada *et al.*, 2009; Liang *et al.*, 2007; Saveyn and Regemorter, 2007). In Indonesia, government agency has made energy outlooks at national level until 2030 and 2050 (BPPT, 2013; MoEMR, 2010b). A number of similar studies have been conducted to make long term projection of Indonesia's energy demand in order to formulate a more effective energy supply and more efficient energy consumption (Elinur, 2012; Ibrahim *et al.*, 2012; Sugiyono, 1999), also to increase energy export potentials (Fukushima, 2002).

However, the impact of the taken policy should be analyzed so that the stated goals can be achieved. The research analyzing interaction among

Indonesia's alternative energy policy has not been done by many. The study that had been conducted is the policy of fuel price subsidy towards the economy by using the econometric model (Hope and Singh, 1995). The analysis of policy scenarios of energy diversification was performed with a dynamic model by BPPT (2012) and a computational model of general equilibrium by Sugiyono (2009), also analysis of policy scenarios of biofuel in transportation sector by BPPT (2013) and Sugiyono (2005). Nevertheless, the analysis of policy scenarios to reduce dependence on oil imports has not been done in Indonesia, so it will be done in this study.

1.2 Research Scope and Problem Statement

The scope of this research includes the analysis of policy scenarios to reduce oil imports dependency on energy demand and supply in Indonesia's economy based on its potential energy reserves and resources. The scenarios used are the rise of subsidized domestic fuel's price, the increase in crude oil production and refinery efficiency, the diversification of fuel in the transportation and power generation sector. The linkage between energy needs and the economy brings the use of multi-sectoral econometric methods for analyzing policies. The dependence on oil imports is calculated as a balance between consumption and production net of exports.

Based on the research background and above description, this research focuses on reducing the high dependence on oil consumption and its imports that may bring negative effect towards national energy security and economy in Indonesia. Thus, there are three problems needed to be answered in this study:

1. What are the influences of the determinators among the analyzed factors on the need of oil imports in Indonesia?
2. How is the estimation of Indonesia's energy demand until 2030?
3. How are the effects of the factors determining oil import towards Indonesia's energy demand in 2030?

1.3 Research Purpose and Benefit

Based on the research background and problem statement, below are the objectives of this study:

1. Examine the factors influencing and determining oil import in Indonesia
2. Makes projection of Indonesia's energy needs until 2030
3. Simulates various alternative strategies of the factors to deal with oil dependency and energy demand.

Hence, the benefits of this research are:

1. Providing information for decision makers, such as:
   a. Ministry of Energy, Mineral, and Natural Resources, Ministry of Finance, Ministry of Industry, and Ministry of Transportation, as an input to prepare integrated development strategic programmes and national energy security

   b. Ministry of Energy, Mineral, and Natural Resources and Ministry of Finance, as an input for oil subsidy policy and projecting balance of payments and national reserves
   c. National energy industy, to expand product research and development strategy
2. Theories and literatures, such as:
   a. Methodology contribution through modifying IEA's world energy model by including non-fossil energy into the model
   b. Enrichment of empirical studies of energy demand behavior at disaggregate level per user sector and type of energy
   c. Provide an overview of energy sector and its relation to Indonesia's economy condition which can be a reference for academics and society to conduct similar study
   d. As an individual report that can be used as mathematical analysis on government's or other institution's reports.

1.4 Research Significance

This study has significance in analyzing various scenarios of energy policy to be taken in order to appropriately reduce dependence in oil imports and support the availability of national energy in the future. In addition, the research brings novelty that it modifies IEA's world energy model by including non-fossil energy into the model.

1.5 Research Systematics

This dissertation contains five chapters:

Chapter I: INTRODUCTION

This chapter consists of research background, research scope and problem statement, research purpose and benefit, research significancy, and research systematics.

Chapter II: LITERATURE REVIEW

This chapter consists of theoretical concept and literature review, research framework and hypotheses.

Chapter III: RESEARCH METHODOLOGY

This chapter consists of research design, type and source of data, data collection procedure, analysis method, and research model.

Chapter IV: RESULT AND ANALYSIS

This chapter consists of finding and data analysis, hypothesis discussion, validation analysis, baseline analysis, simulation analysis, and energy efficiency analysis.

Chapter V: CONCLUSION AND IMPLICATION

This chapter consists of conclusions, research limitation, managerial and theoretical implication, and recommendation for future research.

CHAPTER II

LITERATURE REVIEW

2.1 Theoretical Concept

2.1.1 Energy

Energy plays a fundamental role in shaping the human condition. Before the modern era, people relied for power on their own muscles, muscles of domesticated animals, such as horses and oxen, and water and wind. The modern era began with the eighteenth-century's introduction of steam power to British coal mining by Thomas Savery and Thomas Newcomen. The scarcity and high cost of good coal on the Pacific Coast combined with discoveries of petroleum in southern California resulted in the development of oil as steam fuel, which unseated coal as steam fuel during the first half of the twentieth century.

Gasoline demand increased after the development of steam engine since the Industrial Revolution in the 1780s. Petroleum, which had been used to meet the needs for engine lubrication in 1860s, began to rival the use of coal, especially after the price had gone cheaper. The use of oil increased after the development of internal combustion engine, while kerosene was being widely used for household lighting. By the early nineteenth century, progress in the field of electricity had induced the development of coal power plants, lowering the share of kerosene. Natural gas slowly entered energy market after long-distance transportation technology was developed at low cost in the 1930s. Natural gas could compete with oil because it was relatively cleaner, cheaper, and more comfortable.

In general, the dominant and popular energy being used today is the non-renewable fossil fuel, such as oil, natural gas, and coal. This energy source is formed from compressed vegetation in shallow sea environments over the course of million years. Since fossil fuel is a finite resource, it is undeniable that someday we will run out of it, or more importantly, not being able to produce it at the same rate and cannot replace it with a new one.

Classification of energy sources in energy economy is equal to the natural resource economy based on its availability, utilization, and commercial value; as shown in Table 2.1 Classification of Energy Sources.

Tabel 2.1 Classification of Energy Sources

Availability	Commercial Value	Utilization
1. Renewable	**1. Commercial**	**1. Primary**
- Geothermal	- Oil	- Oil
- Hydropower	- Gas	- Gas
- Solar	- Coal	- Coal
- Wind	- Uranium	- Geothermal
- etc.	- Geothermal	- Hydropower
	- Hydropower	
2. Non renewable	**2. Non commercial**	**2. Secondary**
- Oil	- Firewood	- Electricity
- Gas	- Agricultural waste	- LPG
- Coal		- Gasoline
- Uranium	**3. New energy**	- Gas
- etc.	- Solar	- Coal bricket
	- Wind	- etc.
	- Ocean	
	- Biomass	

Source: Yusgiantoro (2000)

National Energy Policy

National energy policy is a part of public policy. Suharto (2005), argue that public policy is everything related to the government's decision of taking actions that would be considered good impacts to the lives of its citizens. Public policy shows a concept to determine specific actions covering various fields such as economic, social, cultural, political, security, and environmental. Energy policy is a public policy of energy supply and its use from economic, social, political, environmental, and national security aspect.

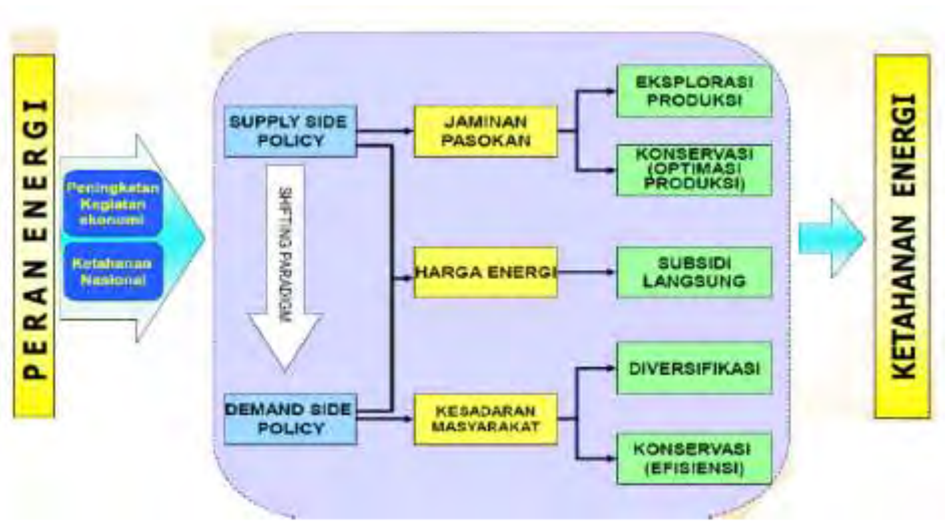
Until 1970s, Indonesia was still considered having abundant energy sources. The main issue was the government’s effort to increase oil production through production sharing contract. By increasing oil production, government’s revenue from export commodity was expected to increase as well.

Indonesia's energy policy first emerged in 1976 with a goal to maximize energy resources utilization. National Energy Coordinating Agency (BAKOREN) was formed in order to formulate energy policy and coordinate its implementation. The Policy of Energy Division (KUBE), which was the first emerging policy in 1984, was updated in 1990 and contained the government's policy to conduct energy intensification, diversification, and conservation. It was followed by KUBE in 1998 with the aim to create a climate supporting the implementation of energy development strategy and providing certainty for economic players, including procurements, suppliers, and sector energy users (Yusgiantoro, 2000).

Energy intensification is conducted through increased survey and exploration activities to determine the economically potential energy. Diversification is an attempt to diversify the use of non-fuel energy by reducing the use of oil and setting other energy source as the primary fuel. Conservation refers to reducing energy through using energy tools more efficiently.

In general, energy policy's aim to reduce dependence on petroleum as energy source through diversification and intensification has been quite successful, but the other goal of making efficient energy use through energy conservation has been failed. These might happen due to the contradiction between the policy of conservation and oil subsidy that would trigger inefficient oil consumption (Sugiyono, 2004).

Figure 2.1 National Energy Policy Concepts in National Development



Source: Directorate of Energy, Mineral, and Mining (2012)

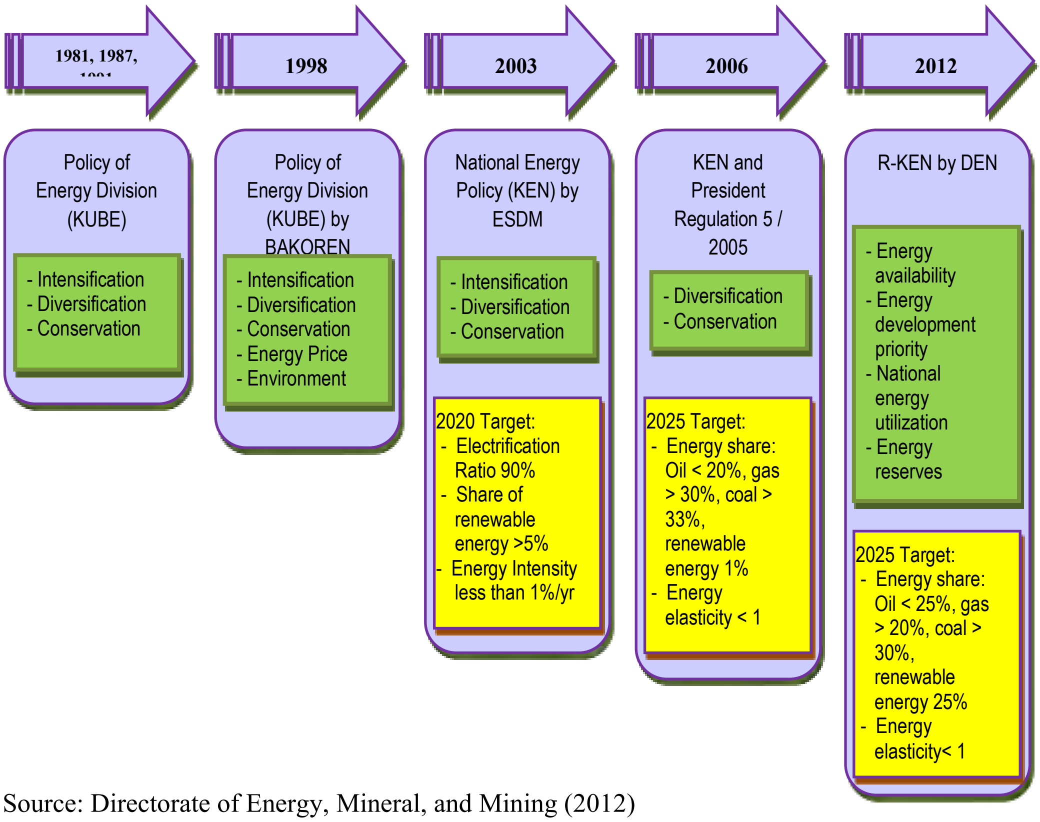
In 2004, Ministry of Energy and Natural Resource (MoEMR) and stakeholders prepared the draft of National Energy Policy as an update of KUBE 1998. Induced by the high oil dependence in primary energy mix, the government issued Law No. 30/2007 on Energy, which will hopefully be able to answer the energy problem. In the era after the Energy Law, national energy policy will shift not only aimed at securing energy supplies but also including the policy of energy use.

National Energy Policy (KEN), which was formulated by the National Energy Council (DEN) at the basis mandate of Law No. 30/2007 on Energy, included energy policy directions for oil and gas, coal, and renewable energy (biofuel, geothermal, solar, and ocean energy) as a policy of energy management based on the principle of equity, sustainability, and environmental concern in order to create national energy independency and security. In substance, the national energy policy (KEN) included:

a. Energy availability for national demand
b. Energy development as a priority
c. Utilization of national energy resources
d. National energy reserves

KEN was prepared energy policy in 2008 with a target to 2050. KEN's scopes of work are different with the previous energy policy, as shown on Figure 2.2.

Figure 2.2 Comparison of National Energy Policy Focus from 1981 to present



Source: Directorate of Energy, Mineral, and Mining (2012)

2.1.2 Economy

2.1.2.1 Economic Growth Theory

Economic growth is one of the indicators of nation's success in economic development (Todaro and Smith, 2006). Economic growth can be defined as the output increase process per capita in a given period. Growth as a process describes dynamic economic development process over time. Output per capita associates the total output (GDP) and population.

The theory of economic growth is essentially a logical "story" about how the process of growth occurs. This theory explains two things, (1) the factors determining the increase of output per capita in the long run, and (2) how the factors interact with each other resulting in the growth process. There are many theories of economic growth, but no single theory can comprehensively be the main standard since each theory has its own model and characteristics according to its own background.

This sub section will discuss the development of several economic growth theories, starting from the classical growth theory to the endogenous growth theory related with the main elements of this research, which are technology and energy.

Based on the historical aspect, the evolution of economic growth started from the Adam Smith and Ricardo's classical economic stating that the accumulation of capitals is a key factor that affects the rate of economic progress. This factor still becomes the main theme of neo-classical economy theory in analyzing the source of economic growth, such as Harrod-Domar and Solow. Harrod (1939) and Domar (1946) stated that investment will quickly push aggregate income and at the same time increase the potential output of the next period. Solow (1956) saw the possibility of increasing human living standard with technological process as an exogenous factor through labor efficiency. It was followed by endogenous growth theory initiated by Romer (1986) which completed the neo-classical theory by including technological process as an endogenous factor. Production function includes labor (L), capital (K), human resource (H), and technological change (A).

According to Romer, technology is seen as endogenous factor related to energy. The technology used today is heavily influenced by the availability of energy; for example, the machinery and electronic industry means nothing if there is no energy. As in the laws of thermodynamics, "no production process can be driven without energy conversion". Energy is not a major determinant in the development of technology, but it is an important factor in the use of technology. The processing of the energy itself requires high technology and high amount of capitals and labor, so the use of energy for productive activities directly through technology will increase revenue.

A. Classical Growth Theory

The rationale of the classical theory is economic development based on liberal system; economic growth is driven by the passion to get the maximum profit. When profit rises, saving and investment will increase as well. This will increase the existing capital stock. The increase of production scale increases demand for labor followed by incremental wages. The next result is the increase of labor supply which will reduce the level of productivity and profit because of the law of diminishing return since the amount of natural resources is limited.

This process resulted in further decrease in production, labor demand, and wage level. According to classical concept, in this condition, the economy experiences a level of saturation or stationary state. This is a situation where the economy has fully grown, well established, and has a prosperous society, but with no further development.

Theory of Smith (1776) in his book *An Inquiry into the Nature and Causes of the Wealth of Nations*, assumes the factors influencing economic growth is the availability of land or natural resources (*N*), total population (*L*), and stock of capital goods (*K*). According to Smith, natural resource is the most fundamental of human's production activities. The number of natural resources is a maximum limit to economic growth. If the resources have not been fully used, then the population and existing capital stock play a role in the output growth. Thus, output will stop growing when all the resources have been fully used.

Human resources have a passive role in the process of output growth. Assuming that wages tend to be the same as the large of minimum living needs; if the rate of current wage is above the minimum level of requirement, then the number of labor will increase, competition in finding a job will be sharper and driving wages back down to a level equal to the minimum requirement level. Thus, the population growth will increase output or outcome.

In contrast, capital stock is one of the production elements that actively determine output level. The number and the rate of output growth depend on the growth of capital stock. The larger the stock of capital, the greater the possibility of specialization and division of labor which will increase the productivity per capita. Smith also recognized the importance of the technology development to improve worker's productivity through increased capital. Capital is obtained by setting aside income or saving

As explained in Rynn (2001), Ricardo first claimed that if one has a particular fixed area of land, the addition of more and more labor will result in diminishing returns to each additional unit of labor. If both land and labor are increased at the same rate, however, there may be no diminishing returns but constant returns to scale, which is a state where there is no reason for diminishing returns to operate, since all factors grow in balance, and all economies of large-scale production have already been realized.

Ricardo on Kurz and Salvadori (2001) explained that as capital accumulates and population grows, and assuming the real wage rate of workers are given and constant, the rate of profit is bound to fall due to extensive and intensive diminishing returns on land, with every increased portion of capital employed on it, there will be a decreased rate of production. Since profit is a residual income based on the surplus product left after the used up means of production and the wage goods in the support of workers have been deducted from the social product (net of rents), the decreased rate of production involves a decrease in profitability. On the assumption that there are only negligible savings out of wages and rents, a falling rate of profit involves a falling rate of capital accumulation. Hence, Ricardo's natural course of events will necessarily end up in stationary state.

Ricardo was one of the first to point out that technological progress can take several forms associated with different implications for the system, performance, growth, employment, and the sharing out of the product between wages, rents and profits. The idea of neutrality of technical progress as it is necessarily entertained in steady-state growth theory was alien to Ricardo's thinking.

B. Neoclassical Theory of Growth

In neoclassical economics, the entire edifice of the theory of growth is built on a concept of decline – the concept of diminishing returns. Because of this reliance on the concept of diminishing returns, neoclassical economics' growth theory has left most practitioners unsatisfied as it now stands. Neoclassical economics theorists, like Solow, use technology as an explanatory variable when other concepts are seen as not having sufficient explanatory power.

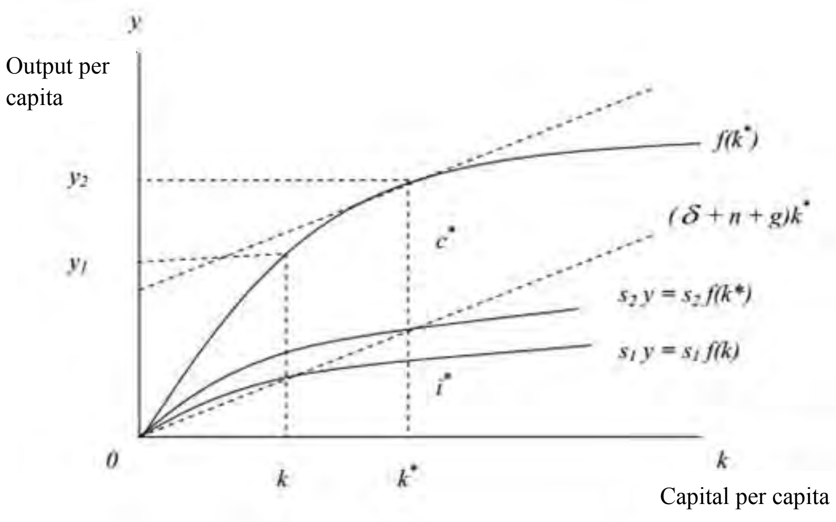
One of the basic assumptions of Solow's model (1956) is the presence of constant return to scale when the input is analyzed simultaneously. However, when analyzed separately, the input assumptions used are diminishing return to scale (Todaro and Smith, 2006). Advanced technology is defined as the residual factor to explain the long-term economic growth. Solow and other theorists assumed the growth to be exogenous or not influenced by other factors.

It starts with the incremental capital per worker that will increase output per capita, but when the capital increases continuously, there will be diminishing marginal product of capital. Similarly, the economics saving rate indicates the size of capital stock and production level in the long term. The higher saving rate leads to the higher capital stock and output. Incremental saving lead to a rapid period of growth, but then slowing down after the steady state is reached, as shown in Chart 2.1 Solow's Model of Growth.

Solow's model explains that economic growth is a long-term determinant through the advance of technology that comes from outside the model. When the economy reaches a steady state, technological advance need to be incorporated into the model, which will induce people's ability to produce all the time. Advanced technology connects the production functions of capital (*K*), labor (*L*), and output (*Y*) with a new variable called labor efficiency (*E*) or labor knowledge about production methods. Labor efficiency increases when there are progress in technology and improvement in medical, education, and labor skills. The equation of the model can be written as:

$Y = f\,(K, L, E)$ …………………………..…………………………… (2-1)

Chart 2.1 Solow's Model of Growth



Source: Mankiw (2007)

C. Endogenous Theory of Growth

Endogenous theory of growth or new theory of growth was developed to enhance the neoclassical theory of growth by stating that technology can prevent the occurrence of diminishing marginal product of capital.

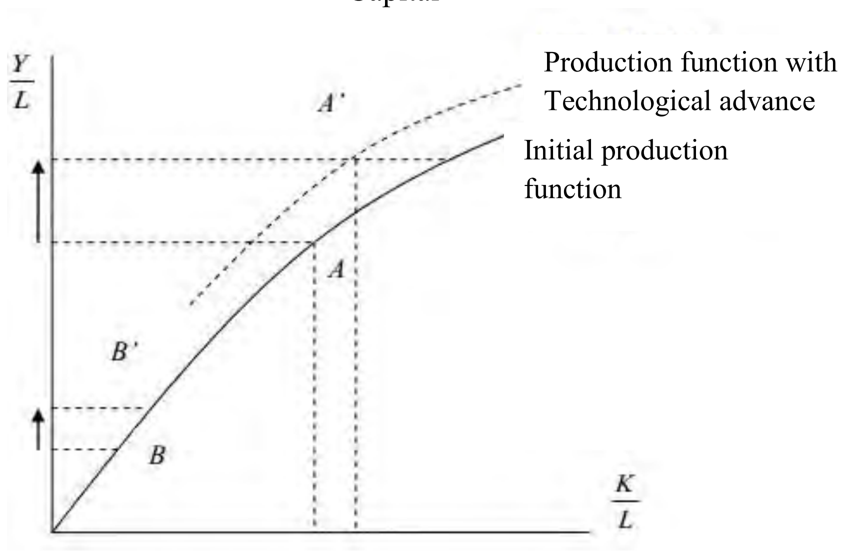
Endogenous theory of growth was first presented in 1986 when Romar included knowledge as production factor input. The purpose of this theory is to explain a long-run growth process by including technology as an endogenous variable, with the following aggregate production function:

$Y = f\,(A, K, L, H)$ ....…………..….. (2-2)

A is for technology, *K* for capital stock, *H* for human resource, and *L* for labor.

In endogenous theory of growth, savings will affect growth process through the forming of capital for investment, thus allowing the development of human capital and technology. Technology is one of dynamic production factors. Similarly, human factors, labor knowledge and quality in production function are no longer exogenous factors, but it can be developed following technology and science development.

Chart 2.2 Technological Advance Prevents the Diminishing Marginal Product of Capital



Source: Kasliwal (1995)

2.1.2.2 Keynes' Theory of Consumption

Keynesian theory of aggregate demand is a relationship between aggregate demand and income or output. The component of aggregate demand such as consumption (*C*), investment (*I*), government expenditure, and (*G*) foreign trade (*NX*) are factors determining the amount of output or income.

Consumption is equal to output or income; the production process is essentially the produced goods and services to be purchased by households in the form of aggregate demand. Besides, the production process also gives return or income for production factors used in production process. For example, the labor used in production process will get wages as the income. Furthermore, this income will cause an aggregate demand in economy or household consumption. But not all of the income is used for consumption; some of it is stored in the form of saving (*S*). Thus, the uses of the income are for consumption (*C*) and saving (*S*) or $Y = C + S$ ……………...…………. (2.3)

According to Keynes, consumption is determined by income. The relationship between income and consumption is positive, means that if income rises, consumption will also increase and vice versa. Besides, consumption will be influenced by consumer's behavior called Marginal Propensity to Consume (MPC) with a value between zero and one. In a linear regression equation, it becomes:

$C = Co + c\ Yd$ .... (2-4)

Note:

C = Consumption

Co = Autonomous consumption

c = Marginal Propensity to Consume (MPC)

Yd = Disposible income, that is income minus tax

In its application in energy, especially in oil, Keynesian consumption theory states that oil consumption will have positive relationship with national income or income per capita. This can be seen in the incremental number of vehicles and home appliances that can directly increase oil demand.

2.1.2.3 Theory of Demand

Demand indicates the number of goods and services to be purchased by consumers in particular period of time and circumstances. The relationship between consumers' demand and other factors that influence buying decisions is commonly described in a mathematical equation called the demand function. Demand function is often associated with commodity prices only, while other factors affecting demand are set as homogeneous or fixed (ceteris paribus). This allows the representation to be two-dimensional graph only.

There are two ways of obtaining demand function. *First*, demand function that derived from utility function when commodity being a final consumption is called Marshallian demand function or Marshallian demand equation (money-income held constant) (Clements *et al.*, 1996) or consumer's ordinary demand function (Hanemann, 1991; McLaren, 1982; Henderson and Quant, 1980). Marshallian demand function can be obtained from the derivation of utility maximization with a constraint of consumer income (Clements *et al.*, 1996; Cooper and McLaren, 1992; Chambers and Kenneth, 1983; Christensen *et al.*, 1975), thus this behavior is the rationality of consumers' behavior. *Second*, Hicksian demand function is focused on expenditure minimization at certain level of utility (constant). In addition for the commodity price, demand also influenced by other factors such as price of other goods, income, taste, income distribution, population, consumer wealth, credit availability, government policies, and previous demand and income level. The demand theory aims to determine factors that influence demand. Demand has multivariate relation that is determined from many other factors simultaneously (Koutsoyiannis, 1994). This is the mathematical form of both functions:

Marshallian demand function:

$XM = f(Px, Py, I)$ ……..…………..…………………………………….……..... (2.5)

Note:

XM	= Quantity of goods x in demand
Px	= Price of goods x
Py	= Price of goods y
I	= Income

Hicksian demand function:

$XH = f(Px, Py, U)$ …….………………………………….…………………..…. (2.6)

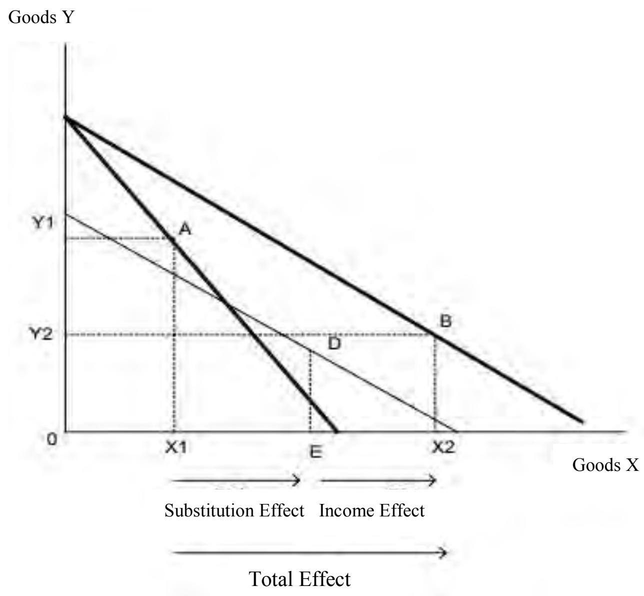
Note:

XH	= Quantity of goods x in demand
Px	= Price of goods x
Py	= Price of goods y
U	= Utility

<u>Subtitution and Income Effect</u>

According to the law of demand, when the price of a good changes, the amount of that good that consumers are willing and able to buy changes in the opposite direction. The economists have identified two important components of changes in price, namely substitution and income effect. The rate of consumption increases as the price of good decreases, the reasons is (1) substitution effect increases the number of goods to purchased, so the consumers' utility moves along the indifference curve, (2) income effect increases the number of purchased goods due to the decreasing price of goods causes greater purchasing power, thus the consumer utility moves to higher indifference curve (Nicholson, 2005).

Chart 2.3 Substitution and Income Effect due to Price Change



Source: Pyndick & Rubinfield (2001) in Nababan (2008)

The explanation of substitution and income effects of price changes is presented in Chart 2.3. Consumer is initially at point A on budget line I_1. Substitution effect is the consumption of good X associated with its price change; the utility level is kept constant. The effect is the change of good X consumption due to its lower price. The substitution is characterized by the movement along the indifference curve. In Chart 2.3, the substitution effect is obtained on the budget line parallel to the new budget line I_2 (which reflects a relatively lower price, that is the price of X), but intersected the initial indifference curve U_1 (keeping the utility level remains constant). The new budget line (I_2) illustrates the fact that the nominal income is reduced to isolate the substitution effect. With this budget line, the consumer chooses to consume a combination of D and X as much as OE. Thus, X_1E line is the substitution effect that always leads to the increase of X goods demand.

Income effect is the change in the consumption of good caused by the increase of purchasing power, while the price of good Y remains constant. In Chart 2.3, the income effect can be seen from an imaginary budget line passing through point D to the new budget line (I_2). Consumers choose a combination of point B on indifference curve U_2 (due to the fall in good X price has raised the level of consumer utility). Increasing consumption of good X from OE to OX_2 is a positive income effect when good X is a normal good (consumers will buy more goods as income increases). Therefore, it reflects the movement from the indifference curve to another curve then the income effect measures the change in consumers' purchasing power. Theoretically, total effect of price changes can be calculated as the sum of substitution and income effect.

2.1.2.4 Theory of International Trade

International trade occurs as a result of interaction between demand and supply in the market, thus creates mutual dependence to meet domestic requirement by cooperating with other countries. Basic term of international trade is gain from trade for each country to maximize their welfare. Term of trade is a quantitative (amount or value) ratio between exports and imports which reflects a country's trade position in a certain period of time.

International trade activities are recorded in the balance of payment which records all economic transactions among countries in a given period. The payment instruments used for international transactions are called foreign exchange, which is received as currency in international community. Foreign-exchange reserves is an indicator showing a nation's economic strength, measured by its ability to finance and creating foreign liabilities (imports and debt payments to foreigners) in a matter of months, using foreign currencies reserved by central bank. Foreign-exchange reserves can be determined from the position of Balance of Payment (BOP).

In this sub-chapter, international trade will be discussed more specifically on relationship between import requirement and economic growth. A country's import requirement may occur due to the excess consumption which cannot be produced domestically (Kindleberger and Lindert, 1982). In other words, import may occur if excess consumption of goods is higher than its production and stocks. It can be formulated as follows:

$M = C - Q + S$ .... (2-12)

M is for quantity of import, C is for quantity of consumption, Q is for production, and S is for stock. According to the concept of traditional import requirement, the dominant factors determining import requirement are national income (Y) and relative price of import (P), (Paulino, 2001). Economic theory also states that import is one instrument that can be used in determining national income. Thus, import directly influences economic growth through changes in national income. By these considerations, import demand function is:

$M = f\{Y, P\}$ .... (2-13)

Several theories explaining the emerge of international trade are the classical theories and modern theories. Classical theories include Mercantilism and the Absolute Advantage Theory by Adam Smith, while Comparative Advantage Theory and Heckscher-Ohlin (H-O) Theory are included on modern theories.

A. Theory of Mercantilism

The adherents of Mercantilism believe that the only way for a country to be rich and powerful is to export as much as possible of and to import as little as possible. The main objective of mercantilism is to gain as much as country's power, so they will be able to maintain a larger army and make a better power consolidation. In addition, more gold means more money in circulation and greater business activity. Furthermore, by encouraging exports and reducing imports, the government will be able to induce national output and employment.

B. Absolute Advantage Theory by Adam Smith

This theory states that a country will export a certain goods because the country can produce the goods at a lower cost than other countries, or has an absolute advantage in its production. The definition of absolute advantage in this theory is the ability of a country to produce a unit of goods or services using fewer resources than other countries. This theory emphasizes that the efficient usage of input in production process will determine the level of advantage or competitiveness.

C. John Stuart Mill and David Ricardo Theory

J.S. Mill and David Ricardo’s Comparative Advantage Theory is a refinement of Adam Smith's Absolute Advantage Theory. J.S. Mill’s theory states that a country will produce and export goods that have greatest comparative advantage while importing goods with comparative disadvantage. David Ricardo (1772-1823), a prominent classical flow states that there will be an exchange value if the item has a value of usability. The development of comparative Advantage Theory into Dynamic Comparative Advantage states that comparative advantage can be created. Therefore, technology and hard work are a country’s success factors. Countries with advanced technology will get a benefit from this free trade, while countries relying on natural resources will lose in international competition.

D. Heckscher-Ohlin (H-O) Theory

The classical theory of comparative advantage explains that international trade can occur because of the differences in the productivity of labor among countries (Salvatore, 2006). However, this theory does not provide an explanation of the cause of the productivity differences.

Relative differences in countries’ resources endowments are key to the standard version of the Heckscher-Ohlin Theory of international trade. This theory states that a country will export the good which requires the intensive use of the country’s relatively abundant (and therefore cheap) factor for its production, and import the good which requires the intensive use of the country's relatively scarce (and therefore expensive) factor for its production. This includes cases in which the natural resource is directly exported (after a minimal amount of processing), rather than being used as an input in another good that is later sold in international markets.

2.1.3 Energy in Economy

2.1.3.1 Energy in Economic Output

Energy is one of the most important natural resources that can affect the output or national production (Stern, 2003; Reksohadiprodjo and Pradono, 1999). Resources which can hinder economic development include land, human, capital, technology, information, and energy. These resources are the production factors or inputs in a production process. Labor, capital, and technology come from human, while natural resources and energy are gifts of nature. The production function is the relationship between the outputs and the number of inputs, which is expressed as follows:

$Y = f(L, K, N, T)$ .... (2-14)

Note:

Y = Output or national production

L = Labor

K = Capital

N = Natural resources

T = Technology

Empirically, using duality principle of production, the physical variables included in the model can be formulated into value of money. Output or national production variable uses GDP data, labor variable uses wage proxy, and capital uses proxy of interest rate. In this study, natural resources variable is the quantity of energy consumption, while technology variable uses proxy of trend. Although an ideal study includes all variables, but the limited data availability and technical estimation allow some variables not to be put into the equation.

Economic growth affects energy consumption through GDP per sector. This study formulated the effects of GDP on energy supply and demand directly or indirectly and vice versa.

In general, output or national production function is defined as follows:

$GDP_i = f\,(W_i, r, Ce_i, GDP_{it-1})$ .... (2-15)

Note:

GDP_i = Gross Domestic Bruto of *i* sector

W_i = Labor wages of *i* sector

r = Rate of interest

Ce_i = Energy consumption of *i* sector

GDP_{it-1} = Lag of GDP

2.1.3.2 Energy Demand Concept

This study will analyze the requirement of energy demand. As consumer goods, the demand function used is the Marshallian demand function that comes from the derivation of consumer's utility maximization, considering income constraint of energy consumers (Varian, 1992; Koutsoyiannis, 1982, Henderson and Quant, 1980). Mathematically, energy consumer's utility function can be written as follows:

$U = f(Ce, Cne)$ .... (2-16)

Note:

U = Consumers utility

Ce = Quantity of energy consumption

Cne = Quantity of non-energy consumption

Using the demand function, Marshallian assumes that consumers will act rationally to maximize its utility in consuming these goods at a certain level of price and income. At the level of energy price *Pe* and non-energy price *Pne*, consumer's income *Y*, then the consumer's budget function can be expressed as follows:

$Y = Pe * Ce + Pne * Cne$ .... (2-17)

Marshallian demand function formulates that consumers will maximize their satisfaction with budget constraints. Using this principle, the formula of energy utility maximization with consumers' income limit using Lagrange function (L) and Lagrange multiplier (λ) is given as follows:

$L = f(Ce, Cne) + \lambda\ (Y - Pe * Ce - Pne * Cne)$ .... (2-18)

Energy demand function will be obtained if the equation (2-18) meets First Order Condition (FOC) and Second Order Condition (SOC), which comes if the first derivative equals zero and the determinant of Hessian matrix is positive. FOC deriving the equation to *Ce*, *Cne,* and λ are:

$\partial L/_{\partial Ce} = Ce - \lambda * Pe = 0$ or $Ce = \lambda * Pe$ .... (2-19)

$\partial L/_{\partial Cne} = Cne - \lambda * Pne = 0$ or $Cne = \lambda * Pne$ .... (2-20)

$\partial L/_{\partial \lambda} = Y - Pe * Ce - Pne * Cne = 0$ .... (2-21)

Substituting equation (2-19) to equation (2-20) will obtain:

$$\lambda = \frac{Ce}{Pe} = \frac{Cne}{Pne} \quad (2\text{-}22)$$

or $$\frac{Ce}{Cne} = \frac{Pe}{Pne} \quad (2\text{-}23)$$

Ce is the marginal utility from energy consumption, while *Cne* is the additional marginal utility from non-energy consumption. Equation (2-23) means consumers' satisfaction in consuming a number of items will be maximum if the satisfaction ratio of additional goods equals the price ratio.

According to Henderson and Quant (1980), the completion of *Ce* and *Cne* is performed by substituting equation (2-21) and (2-22) into equation (2-23) which will result in energy and non-energy demand function as follows:

$Ce = f\,(Pe, Pne, Y)$ .... (2-24)

$Cne = f\,(Pe, Pne, Y)$... (2-25)

This means that energy and non-energy demand are determined by the price of energy, the price of non-energy, and consumers' income. Equation (2-24) and (2-25) are used for energy demand in household sector. In addition to non-household sector, such as industrial, commercial, transportation, and other sectors, energy demand is the input demand to produce output. Thus, the concepts of energy demand theory in the sector also use the concept of input demand theory.

Theoretically, the function of input demand is built on the derivation of profits or the cost function. The first approach is known as profit maximization approach and the second approach as cost minimization, thus both approaches are known as the production duality approach. Both approaches produce the same breakdown (Henderson and Quant, 1980 and Hartono, 2004). Thus, the reduction of input demand function can be done by reducing profit function.

The production function is the relationship between output and input of labor (*L*), capital (*K*), natural resources (*N*), and other input (*Z*). The relationship between output and input are:

$Y = f\,(L,K,N,Z)$ .... (2-26)

From the production function above, the profit function is:

$Л = Pq*f(L,K,N,Z) – λ(Pl*L + Pk*K + Pn*N +Pz*Z)$ ....(2-27)

Note:

$Л$ = Producer's profit

Pq= Price of output Y

Pl = Price of input L (wage)

Pk = Price of input K

Pn = Price of input N

Pz = Price of other input Z

Input demand function will be obtained if meeting First Order Condition (FOC) and Second Order Condition (SOC), which occurs when the first derivative equals zero and the determinant of Hessian matrix is positive (Koutsoyiannis, 1977; Henderson and Quant, 1980, Hartono, 2004). If both conditions are met, the FOC will obtain:

$\partial\pi/\partial L = Pq * L - Pl = 0$ or $Pl = Pq * L$ .... (2-28)

$\partial\pi/\partial K = Pq * K - Pk = 0$ or $Pk = Pq * K$ .... (2-29)

$\partial\pi/\partial N = Pq * N - Pn = 0$ or $Pn = Pq * N$ .... (2-30)

$\partial\pi/\partial Z = Pq * Z - Pz = 0$ or $Pz = Pq * Z$ .... (2-31)

The completion of equation (2-28) to (2-31) will produce the following input demand function:

$L = f(Pl, Pk, Pn, Pz, Pq)$ .... (2-32)

$K = f(Pk, Pn, Pl, Pz, Pq)$ .... (2-33)

$N = f(Pn, Pl, Pk, Pz, Pq)$ .... (2-34)

$Z = f(Pz, Pl\ Pk, Pn, Pq)$.. (2-35)

Note:

L = Demand of labor

K = Demand of capital

N = Demand of natural resources

Z = Demand of other input

Empirically, the energy demand per sector energy users (industry, transportation, household, commercial, and other sectors) covers the energy demand of fuel, electricity, coal, and gas. Houthakker and Taylor (1970) developed a dynamic model which the current condition is determined by the effect of past behavior, and the change of behavior in the future is determined by current condition. Referring to equation (2-32) to (2-35), the energy demand per type is influenced by the price of energy itself, other energy prices (substitute or complement), output prices, and the lagged variable.

Because this study uses macroeconomic approach, the output price comes from sectoral GDP. Thus, sectoral energy demand per type of energy can be formulated (Bohi and Zimmerman, 1984; Bohi, 1981) as:

$Ce_{ij} = f(P_i, Pz, GDP_j, Ce_{ijt-1})$ .... (2-36)

Note:

Ce_{ij} = Consumption of *i* energy at *j* sector

P_i = Price of *i* energy

Pz = Price of other energy

GDP = GDP of *j* sector

Ce_{ijt-1} = Lag consumption of *i* energy at *j* sector

2.1.3.3 Energy in Government Revenue and Expenditure

Energy plays two roles in government finance: as a source of revenue and as spending for fuel subsidy and crude oil import. Government revenue from the upstream energy activities (exploration and exploitation) is obtained through profit sharing based on Production Sharing Contract (PSC) between government and energy contractor with the share of 85:15 for oil and 70:30 for gas. Revenue from downstream sector is obtained from the distribution of final energy products to consumers, such as the taxation of fuel, gas, and electricity to consumers.

Government spending on energy is in the form of subsidies. Government set fuel price for consumers below the cost of production. The differences are borne by the government and called subsidies (Yusgiantoro, 2000). Currently, most of domestic fuel consumptions are from import, thus the difference between the import price and the selling price is also a part of the subsidy borne by government. The amount of subsidy is associated with economic stability policies, economic growth, and politic stability.

2.1.3.4 Energy and the Balance of Payment

The scope of balance of payment includes good or service sales and purchases, grants from individuals and foreign governments, and financial transactions. The balance of payment is divided into two main parts, (1) the current account that covers export and import transactions of goods and services and net transfer payments abroad, and (2) the capital account that covers two levels of transactions, which are long-term capital flows and private capital flows (Sukirno, 2011). The balance of payment is very useful to show a country's structure and composition of economic transactions and its international financial position.

In energy sector, producer and consumer countries have close relation with balance of payment through their energy export and import. Surplus or deficit in balance of payment is affected by energy prices, energy production, and currency rate (Yusgiantoro, 2000). Deficit of trade will reduce domestic economic activity and lose the country's economic prospect in a long run. Then, domestic capital will flow outward and foreign capital will not be invested in the country. This situation may slow down economic growth in the future (Sukirno, 2011).

2.1.4 Sustainable Development

Sustainability is the endurance of system and processes. The organizing principle for sustainability is sustainable development, which includes the four interconnected domains: ecology, economics, politics and culture. According to the Brundtland Commission in 1988, sustainable development is the kind of development meeting the needs of the present without compromising the ability of future generations to meet their own needs.

The concept of sustainability can be explained in weak and strong sustainability. Weak sustainability is the idea within environmental economics, which states that human capital can be substituted by natural capital. Serageldin in Pribadi (2004) explained that the idea focused on efforts to increase prosperity through limited natural resources and technology capabilities. It is based upon the work of Solow (1974, 1986, 1993) and Hartwick (1977, 1978a, 1978b). Contrary to weak sustainability, strong sustainability assumes that human capital and natural capital are complementary, but not interchangeable.

Perman *et al.* in Mendrofa (2012) described three main reasons why development should be sustainable. *First*, regarding morality, present generation enjoying products from natural resources has a moral obligation to preserve the natural resources for future generations, including not to exploit natural resources that can give negative impact to the environment. *Second*, related to ecological reasons, biodiversity has a very high ecological value, thus economic activity should not be directed at things threatening ecological functions. *Third*, economical reasons, currently is still being debated whether economic activities has met sustainability criteria or not.

Energy in terms of economy and environment are: (1) a natural ecology in a geologically and geographically good area usually has abundant energy sources and natural resources, means there is a positive correlation between environment and energy also between environment and economy. (2) However, increasing energy consumption and economic demand will burden environmental capacity which leads to a negative correlation among energy, economy, and environment.

2.1.5 Econometric Model as a Tool of Analysis

Econometric model is a standard approach commonly used in energy demand model end use accounting and input-output model (Battacharyya and Timilsina, 2009). This approach uses a relationship between dependent variable and particular independent variable based on statistical analysis of historical data.

This approach has a close relationship with the theory of consumption and production. Important variables used in the model are taken from related theory and the effects from the variables will be statistically evaluated. The result of statistical analysis from significant independent variables will be considered and used in forecasting to determine their effects on the dependent variable.

Econometric approach has grown significantly in the last 40 years. In 1970s, it evolved to determine relationship between energy and economic variables, as stated by Pindyck (1979):

> *Less definition in responding energy demand in a long run as a result of price and income changes makes it difficult to design energy and economic policy. By using different energy model and international data, we obtained better definition of energy demand structure in long run and its relation with economic growth.*

Econometric model often used to analyze complex economic variables is simultaneous equation model. According to Gujarati (1999), simultaneous equation is a model with more than one dependent variable and more than one equation. A unique characteristic of simultaneous equations is that dependent variable in one equation may appear as independent variable in other equation of the system.

According to Pyndick and Rubinfeld (1998), simultaneous equation can give a better picture of the real world than single equation model. This is because the variables in the equation can interact with each other in the model.

2.2 Literature Review

2.2.1 Economic Growth and Energy Consumption Study

Many literatures of growth theory focus on capital and labor, only a few researches analyze the role of energy and its availability in the growth of economy and production (Stern and Cleveland, 2004). Economists after Adam Smith discussed some important economic inputs, such as land, labor, and capital. Neo-classical began to explain with the development of labor, capital, and technology.

Energy is often mentioned as a production factor separated from labor and capital. Then Stern (2000) conducted a study and showed that energy is an important production factor that can be used directly to produce final product. All production activities and daily activities require energy as an important input, thus energy has an important role in economic growth, industrialization, and urbanization. Alam (2006) developed an alternative economic concept combining energy with capital, labor, and technology as production factors.

The relationship between energy and economy was initiated by Kraft and Kraft (1978) seminal work. Testing the relationship between energy consumption and GDP in United States from 1947 to 1974, the research found unidirectional causality between GDP and energy consumption. Later, Akarca and Long (1980) tested this relationship with the same variables for the same country for 1947–1972 period. Unlike Kraft and Kraft (1978), they could not find any relationship between variables. Erol and Yu (1987) examined the relationship between energy consumption and GDP for England, France, Italy, Germany, Canada, and Japan with the data from 1952 to 1982 and found bidirectional causality for Japan, unidirectional from energy consumption to GDP for Canada, and unidirectional from GDP to energy consumption for Germany and Italy. They could not find any causal relationship for France and England.

Stern (2003) stated that the test including only two variables of energy consumption and GDP was not enough, so he added more generally the roles of energy in the growth process in his study. Using Granger causality and multivariate cointegration analysis, found that energy use per unit of economic output had declined since 1945 until 1995 in the United States as a result of the diversification and conservation of energy. The implications of this energy shifting are the increase of economic growth and positive impact to the environment.

Various researchers focus on panel data to investigate the causal relationship between same variables. Al-Iriani (2006) used a bivariate model for six countries of the Gulf Co-operation Council such as Bahrain, Qatar, Kuwait, Oman, Saudi Arabia, and the United Arab Emirates to find unidirectional causality flowing from GDP to energy consumption, while Lee (2005) used trivariate model with fixed capital formation for 18 developing countries and found the similar result. Mahrera (2007) also found similar results with Al-Iriani for 11 oil exporting countries. Lee and Chang (2007) found bidirectional causality between energy consumption and economic growth in 20 developed countries, while unidirectional causality from economic growth to energy consumption was found in 18 developing countries. Lee and Chang (2008) also found different result of unidirectional causality running from energy consumption to GDP for Asian countries for the period of 1971 to 2002. Imran and Siddiqui (2010) could not find any causal relationship in the long run for Bangladesh, Pakistan, and India for the period of 1971 to 2008, but unidirectional causality flowing from energy consumption to GDP was found in the long run.

Following advances of time series analysis in the last decade, Asafu-Adjaye (2000) examined the energy and income relationship for 4 energy-dependent Asian developing countries: India, Indonesia, Philippines, and Thailand for the period of 1971 to 1995. The results indicated that, in the short run, unidirectional causality runs from energy to income for India and Indonesia, while bidirectional causality was for Thailand and Philippines.

There are a large number of papers examining the empirical relationships between energy use and economic growth. However, evidences from empirical researches are still mixed and controversial in terms of the direction of causality and the intensity of impact on energy policy depending on the methodology used, also on the country and time period studied (Ozturk, 2010).

Following the literature on Cherfi and Kourbali (2012), one may construct four different hypotheses: (1) the neutrality hypothesis states that there is no causality between economic growth and energy consumption. Under the neutrality hypothesis, the policies aimed at conserving energy resources fail to hinder economic growth (Asafu-Adaye, 2000; Jumbe, 2004). (2) The feedback hypothesis states that there is a bidirectional causality running between economic growth and energy consumption. Energy consumption and economic growth are complementary, and the increase in energy consumption stimulates economic growth, and vice-versa. (3) The conservation hypothesis determines the unidirectional causality running from economic growth to energy consumption. When causality runs from economic growth to energy consumption, an economy has less dependence on energy; thus energy conservation policies, such as phasing out energy subsidies, may not adversely affect economic growth (Mehrera, 2007). (4) The growth hypothesis evaluates the existence of the unidirectional causality running from energy consumption to economic growth (Narayan and Smyth, 2005; Ghosh, 2002). According to the growth hypothesis, a country's economy is energy dependent; in this case, the reduction of energy consumption will lead to a fall in economic growth because energy consumption is a prerequisite for economic growth, energy is a direct input in production process and/or an indirect input complementing labor and capital inputs (Ebohon, 1996). This implies that a negative shock to electricity consumption leads to higher electricity price or electricity conservation policies has a negative impact on GDP (Narayan and Singh, 2007).

Besides examining the empirical relation between energy consumption and economic growth, there are large number of papers determining factors affecting the growth of economy and energy. Increasing oil production through investment has a positive effect on economic growth (Wahyudi, 2010), and increasing export value for an exporting country will rise economic growth (Damette and Seghir, 2013; Mahrera, 2007). Hamilton (2012) also investigated the relation among technology, oil price, oil consumption, and GDP in United States and found that technology use in oil exploration and exploitation activities will increase oil production, and an increase in oil price is followed by a decrease in consumption and GDP.

2.2.2 Energy Supply and Demand Study

Since the first oil shock in early 1970s, there has been a significant increase in the number of research studies of energy demand in order to attempt to understand the nature of energy demand and demand response generated by external shocks of that time (Pindyck, 1979). The lively debate between engineers and economists of that era led to important methodological developments that enriched the energy decision-making process as a whole, and a wide variety of models became available for analyzing and forecasting energy demand (Wirl and Szirucsek, 1990).

Energy demand forecasting is essential to analyze the correlation between energy and other factors such as economy, technology, management, and operational research. This is an essential component for energy planning, formulating strategies, and recommending energy policy for government and policy makers based on real and updated condition.

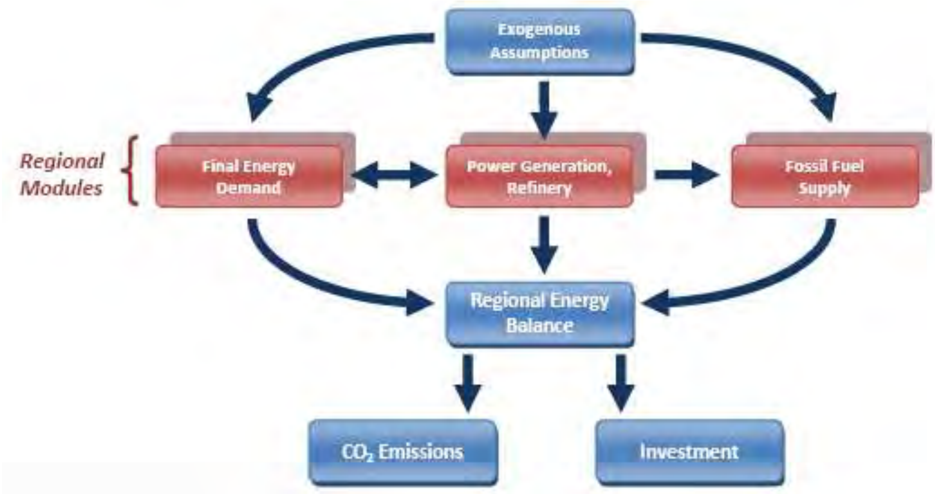
Jebaraj and Inayan (2006) made a paper reviewing various emerging issues related to energy modelling. The different type of models, such as energy planning models, energy supply and demand models, forecasting models, renewable energy models, emission reduction models, and optimization models had been reviewed and presented.

Bhattacharyya and Timilsina (2009) critically reviewed energy demand model in developed countries, just like those which were done by Hartman (1979), Bohi (1981), Bohi and Zimmerman (1984), Craig *et al.* (2002), Worrel *et al.* (2004), Wirl and Szirucsek (1990). Similarly, Urban *et al.* (2007), Pandey (2002), Shukla (1995), and Bhatia (1987) focused on energy modelling from developing countries' perspective. In addition, Cooper (2003), Dahl (1991, 1994a, 1994b), Espey (1998), Dahl and Sterner (1991) provided energy, particularly oil demand elasticity surveys.

Bhattacharyya and Timilsina (2009) also reviewed variety of methods in energy demand forecasting, and grouped the methods according to five categories: (a) end-use modelling, is another widely used energy demand forecasting tradition focusing on end-uses or final needs at a disaggregated level (Worrel *et al.*, 2004; Wilson and Swisher, 1993; Lapillonne and Chateau, 1981); (b) input-output, providing a consistent framework of analysis and being able to capture the contribution of related activities through inter-industry linkages in the economy (Liang *et al.*, 2007; O'Doherty and Tol, 2007; Wei *et al.*, 2006; Tiwari, 2000); (c) econometric modelling is a quantitative approach that generally aims to analyze relationships statistically, usually based on econometric theory or intuition between a dependent variable and independent variables using historical data, (Al-Azam and Howdon, 1997; Erdogan and Dahl, 1996; Ishiguro and Akiyama, 1995); (d) scenario approach, having been widely used in climate change and energy efficiency policy making (Ghanadan and Koomey, 2005); and (e) hybrid approach relying on a combination of two or more methods discussed above with the objective of exploring the future in better way; International Energy Agency (IEA) has been expanding this model in World Energy Model (WEM) since 1993.

WEM is a large-scale mathematical construct design to replicate how energy markets function and is the principal tool used to generate detailed sector-by-sector and region-by-region projections for various scenarios. The model consists of six main modules: final energy consumption per energy sector used; power generation and heat; refinery or petrochemicals and other transformation; fossil fuel supply; CO_2 emissions and investment, as shown on Figure 2.3.

Figure 2.3 World Energy Model



Source: IEA, 2012

The main exogenous assumptions concern economic growth, demographics, international fossil fuel prices, and technological developments. Electricity consumption and electricity prices dynamically link the final energy demand and power generation modules. The refinery model projects throughput and capacity requirements based on global oil demand. Primary demand for fossil fuels serves as input for the supply modules. Complete energy balances are compiled at a regional level and the CO_2 emissions of each region are then calculated using derived carbon factors.

In technical aspect, the parameters of the equations of the demand-side modules are estimated econometrically. To take into account expected changes in structure, policy, or technology, adjustments to these parameters are sometimes made over the outlook period using econometric and other modelling techniques. Simulations are carried out on annual basis. Demand modules can be isolated and simulations run separately. This is particularly useful in the adjustment process and in sensitivity analysis related to specific factors.

Various energy supply and demand studies using different model in Indonesia had been conducted by Elinur (2012), Sugiyono and Suarna (2006), Santosa and Yudiartono (2005), and Sugiyono (1999, 2005).

Sugiyono (1999) made Indonesia's energy demand and supply projection from period 2000 until 2030 using general equilibrium model in two scenarios, i.e. the scenario if there is no economic crisis (NOK) and scenario for the current situation with economic crisis (BAU). Output of the model showed that under NOK scenario, energy demand grew by 4.3% per year and under BAU scenario, the growth was only 2.9% per year. Coal is the main energy source to fulfill the demand if there is no economic crisis. Under the current situation, natural gas and coal have a big share for primary energy supplies.

Motivated by the rapid increase of oil consumption in transportation sector and the concern for higher oil import due to limited oil resources and high oil price, Sugiyono (2005) examined biofuel for national energy supply. Using Model for Analysis of Energi Demand (MAED), he made an energy demand projection until 2025 in two scenarios, i.e. business-as-usual scenario and higher-oil-price scenario. The first scenario assumed 10 percent discount rate, oil price of US$ 40/barrel and biofuel price of US$ 60.5/barrel; while the second scenario used US$ 60/barrel of oil price. Optimization of the objective function by minimizing total energy cost with constrains of limited resources and technology was applied in each case to see the opportunity of biofuel use.

The results showed that neither biodiesel nor bioethanol could compete with oil fuel in the base case because cost of biofuel was still higher than conventional fuel or compressed natural gas (CNG). Transportations powered by diesel and gasoline were more economic than those using CNG and biofuels. In case of high oil prices, biofuel has potential to be used for transportation. The sensitivity analysis showed at US$55/barrel oil price, biofuel has an opportunity to compete with fuel. It was estimated that biofuel demand will increase at 2025 in amount of 103 million BOE. CNG use for transportation will also increase to 20.6 percent of total energy consumption at 2025.

Sugiyono and Suarna (2006) studied electricity supply until 2030 using MARKAL. The results showed that coal will dominate power supply energy source with a share of 58 percent or growth of 9.7 percent per year. Renewable energy has a share of 20 percent and gas 19 percent.

Santosa and Yudiartono (2005) made Indonesia's energy demand projection in a long term per sector use and regional by linking the macroeconomic aspects, such as GDP, demography, growth of electricity demand, exports and imports of energy, and national energy reserves. The study found that the declining population growth from 1.24 percent to 0.89 percent and increasing GDP growth from 3.2 percent to 6 percent per year caused increasing energy needs in average of 4.8 percent per year. The highest energy demand with growth of 5.1 percent was in Java and the smallest growth was in Sumatera of about 4.5 percent. Java had the largest share of energy in amount of 50 percent while the smallest share in Kalimantan had about 8 percent. Energy demand in transportation sector increased rapidly in line with GDP compared to other sectors. Electricity demand for residential increased higher than non-residential sector, indicating that economic level and households' quality of life in Indonesia has been getting better.

Elinur (2012) also made a study to determine factors affecting energy supply and demand, analyze economic policies and other external factors to energy supply and demand, make a projection of energy supply and demand per sector energy use, analyze energy efficiency, formulate effective energy supply strategy and efficient energy consumption policy in Indonesia.

Using WEM estimated with econometric method, the study found: (1) world oil price, domestic oil price, GDP, and currency rate are the main factors affecting energy demand and supply, (2) increasing world oil price and declining government spending for energy subsidy decreases energy supply and demand, while rupiah's appreciation against dollar will increase energy supply and demand, (3) energy demand is projected to increase until 2030.

The application of energy demand and supply model can be used to estimate energy import requirement, like Adams *et al.*, (2000) analyzing for Thailand, Adams and Shachmurove (2007) for China, Tubss (2008) for United States, Ghosh (2009) for India, Nakanishi and Komiyama for Asian countries and the world, and Dilaver (2012) for Turkey.

Using simultaneous equation of energy balance model in Thailand for period 1978 to 1993, Adams *et al.*, (2000) made projection of future energy needs until 2010 and tested various alternative strategies to deal with energy dependence. From 1984 to 1993, Thailand's economic growth and energy consumption were 8.6 percent and 10.3 percent, showing that Thailand, which was deficient in energy and was growing very rapidly will bear, *ceteris paribus*, a heavy energy import cost. The baseline forecast showed rapid and continuous increase of total energy consumption at 10-11 percent per year, and oil import will increase 6 times from 1992 or increasing to an amount of 129 million tons in 2010. Relatively to real GDP, the increase of petroleum imports was 9 percent per year against 7.7 percent per year for GDP over the 1996 to 2010.

The study suggested that the growing energy needs will not impose a serious burden on Thailand's economy as long as there is continuous growth in export and oil price does not increase sharply relative to the value of other goods in world market. Thus, additional domestic energy production or improvement on efficiency can help somewhat to lower the tendency of energy import exceeding economic growth.

In 2007, Adams and Shachmurove predicted China's energy demand from 2010 until 2020 using energy balance model and econometric approach. China's energy demand rises rapidly due to the needs to support its economic growth. Recently, net crude oil import has been accounted for 28 percent of total Chinese crude petroleum use and increases 15 percent annually or equivalent to 3.5 percent of total world's crude oil trade.

The prospects of China's energy demand for 2010 to 2020 increases at annual rate of 4.8 percent in 2010 to 2020 or lower than the growth of GDP, indicating aggregate energy elasticity of 0.74. Coal consumption declines 6 percent per year due to energy diversification, high tech industry, and many substituting goods out of coal. Meanwhile, petroleum product, gas, and electricity demand increase as a result of increasing motorization at transportation sector consuming the majority of petroleum products. Thus, petroleum imports in 2020 are likely amounting to almost 12 million barrels/day or almost 20 percent of world imports at that time. This paper also suggested that China's energy import will be more sensitive to the increase in motorization rather than economic growth. Imports of coal in 2020 may reach more than 50 percent of world trade in coal for electricity.

Canada's economy is deeply integrated with the US' economy as a background; Tubss (2008) simulate various climate policy scenarios to the energy forecast demand between Canada and the US. It suggests that future output by Canadian energy sector is less when there is a price on emissions in Canada and vice versa.

Ghosh (2009) found that the long term income elasticity of imported crude in India exist a unidirectional long run causality running from economic growth to crude oil import and price elasticity estimation is not significant. So, the reduction of crude oil import will not affect the India's future economic growth in the long run. India should take various energy efficiency and substitute imported fuel by domestic fuel to reduce its dependence in import.

The research to determine Indonesia's crude oil import was conducted by Kirana (2005). Dynamic linear model estimation of Error Correction Model (ECM), t-test, f-test, and classical econometric assumption test were used to examine crude oil production, world oil price, currency rate between rupiah and dollar, crude oil export, oil consumption, and crude oil import in Indonesia. Empirical results showed that oil production, oil price, currency rate, and oil export had a significant negative effect while oil consumption had significant positive effect in short and long run. This research suggested Indonesia should increase its productivity in oil production, implement energy efficiency, and substitute oil by alternative energy to reduce its import dependence.

Meanwhile, Zhao *et al.*, (2007) found that the sectoral growth of industrial production and transportation expansion are important factors influencing China's oil import for the period 1990 to 2001. Using co-integration and Vector Error Correction Model (VECM) techniques, the research investigated the determinants of China's energy import demand, such as oil price, growth of industrial production, transportation, and diversification.

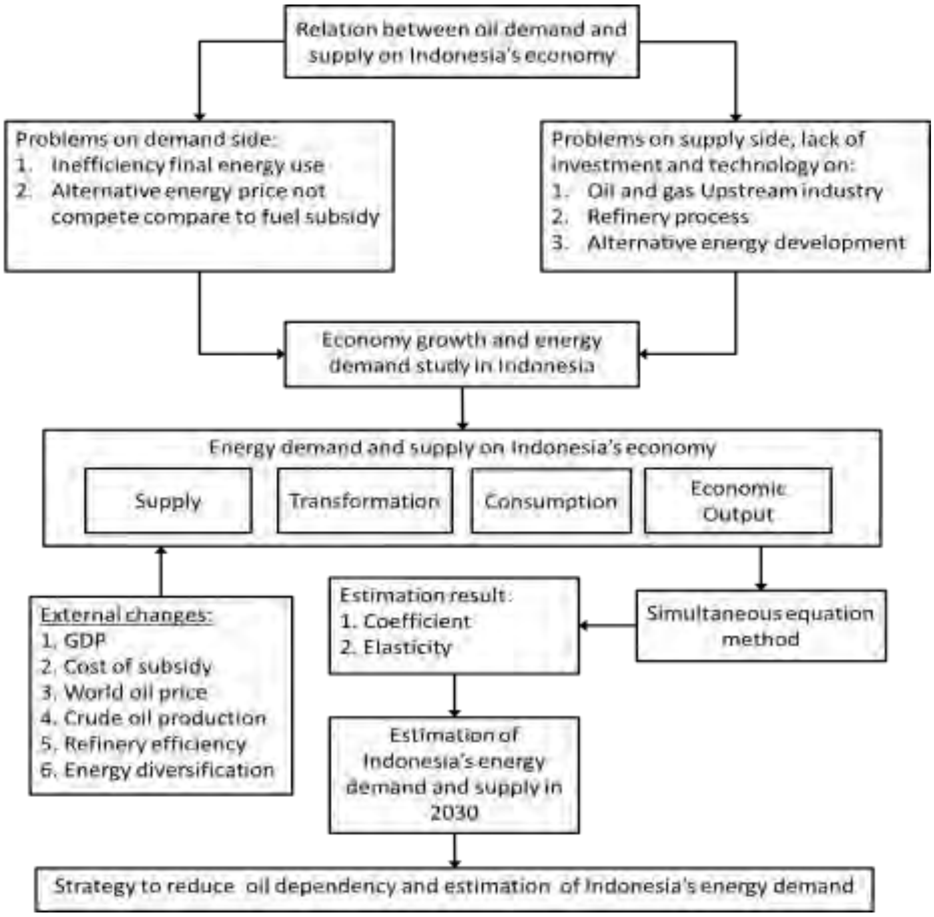
Royfaizal (2008) used Granger causality test and found that crude oil import will not affect the future economic growth and the price of imported crude oil in Japan in the long run for period 1992 to 2006. This indicated that the reduction of crude oil demand due to energy efficiency and diversification will not affect Japan's future economic growth and price in the long run.

2.3 Research Framework

Based on the concept and empirical research that have been described in the previous section and referring to the problem statement and research objectives, research framework is created as in Figure 2.4. Research will be completed by develops an energy balance model in Indonesian economy as shown in Figure 2.6.

Modifying World Energy Model (WEM) from International Energy Agency (IEA), research will include non-fossil energy such as geothermal, hydropower, and biomass on energy supply model instead of only fossil energy on WEM as shown in Figure 2.5.

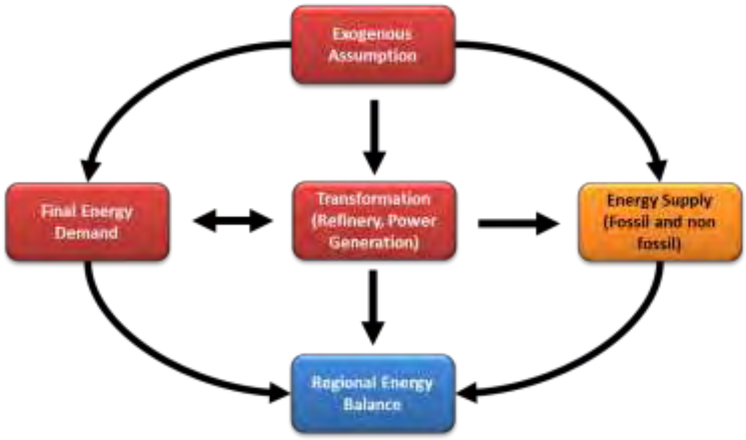
Figure 2.4 Research Framework



Source: processed data

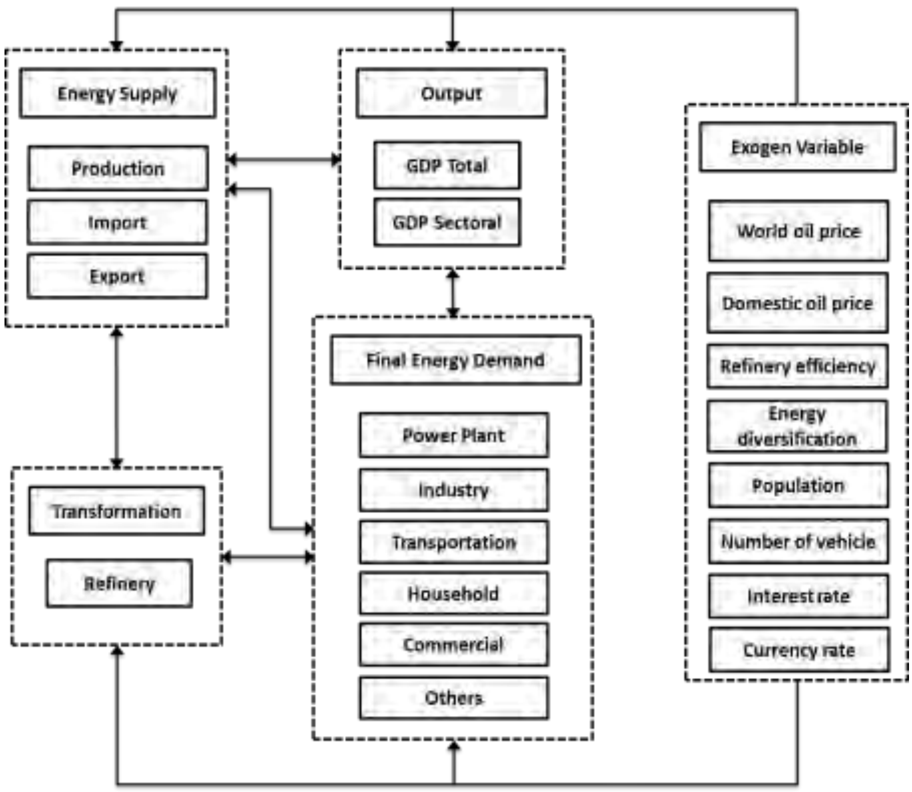
The model consists of four main modules, i.e. final energy consumption per energy sector used, transformation, fossil and non-fossil energy supply, economic output; and exogenous assumption. Each module on this model is a linkage making up the balance. To predict Indonesia's energy demand into 2030, simultaneous equation on econometric model is constructed based on its energy balance. Estimation will be made with consideration of national energy policy in 2030.

Figure 2.5 Modification of World Energy Model



Source: IEA (2012), modified

Figure 2.6 Energy Balance Model in Indonesia



Source: processed data

Simulation of external variable changes like the increasing GDP, lower subsidy cost, increasing world oil price, increasing production of domestic crude oil, more efficient refinery, and energy diversification will be run to see the effect of each variable on energy and oil import requirement. The results are expected to be an input for government policy in order to maintain national energy and economic sustainability.

2.4 Research Hypotheses

Hypothesis is a statement which is temporarily accepted and its truth will be tested using the right model and analysis. Research hypotheses were formulated based on their frameworks as temporary explanation of problem statement. Regarding their research framework, theoretical concept, and first problem statement, the hypotheses can be developed as follows:

There are large number of papers examining empirical relationships between energy use and GDP in the countries (Ozturk, 2010) and found that there was a relationship correlation between energy consumption and GDP (Apergis and Danuletiu, 2012; Binh, 2011; Adebola, 2011; Lau *et al.*, 2011; Imran and Siddiqui, 2010; Chary and Bohara, 2010; Khan and Qayyum, 2007; Siddiqui 2004). Then, energy import will increase through growing energy consumption (Zhou, 2012; IEE, 2009; Fukushima, 2000; Adams *et al.*, 2000; Intarapravich *et al.*, 1996). Based on the explanation above and the fact that oil is an important energy in Indonesia, the operational hypothesis is:

Hypothesis 1:

Ho: There is no relationship between GDP and oil import through fuel consumption

Ha: There is a relationship between GDP and oil import through fuel consumption

In addition to GDP, Meier *et al.*, 2012; Hamilton, 2012; Ghosh, 2009; Nourah, 2005 and Boug, 2000 analyzed that energy price also affects energy consumption. In terms of differences between imported oil price and domestic fuel's selling price, this research creates two hypotheses for oil price; these are world oil price and subsidized fuel price.

Hypothesis 2:

Ho: There is no relationship between subsidized domestic fuel price and oil import through fuel consumption

Ha: There is a relationship between subsidized domestic fuel price and oil import through fuel consumption

Hypothesis 3:

Ho: There is no relationship between world oil price and oil import through fuel consumption

Ha: There is a relationship between world oil price and oil import through fuel consumption

In order to increase their energy surplus, oil producers and exporter countries seek to increase oil reserves and production through exploration and exploitation activities (Starbuck *et al.*, 2010; Ghebremedhin and Schreiner, 1983).

As a country having oil reserves and refinery process, Indonesia needs to increase its production of crude oil and the processed oil products through the efficiency of refinery capacity in order to reduce oil imports in the form of crude oil and fuel. Pablo (2010) stated that the declining oil reserves and its production in United States will increase oil import requirement. Based on the description, the operational hypotheses are:

Hypotesis 4:

Ho: There is no relationship between crude oil production and oil import

Ha: There is a relationship between crude oil production and oil import

Hypotesis 5:

Ho: There is no relationship between refinery efficiency and oil import

Ha: There is a relationship between refinery efficiency and oil import

Energy diversification is the practice of a country using multiple energy sources like natural gas, coal, and the renewables to replace the use of oil. Research from Danar, 1994; Sugiyono, 1999; IEE, 2009; Ghosh, 2009; Zhao, 2008; Elinur, 2012 and Ibrahim 2012 suggested that energy diversification is one of energy strategies to reduce oil dependency. Then, the operational hypothesis is:

Hypotesis 6:

Ho: There is no relationship between energy diversification and oil import through fuel consumption

Ha: There is a relationship between energy diversification and oil import through fuel consumption

CHAPTER III

RESEARCH METHODOLOGY

3.1 Research Design

This research uses descriptive and quantitative design. Descriptive research is used to describe Indonesia's energy and economy condition for the period 1990 to 2011 which will be translated into econometric model to measure relationship between economy and import requirement. It is followed by quantitative research to utilize data collection and analyze using statistical and simulation techniques to answer research questions.

3.2 Data Types and Sources

This research uses secondary data at a state level time series of yearly observation from 1990 to 2011 as issued by Ministry of Energy and Mineral Resources, Central Bank of Indonesia, Central of Statistical Bureau, Directorate General of Land Transportation, and other supporting sources.

3.3 Data Collection Procedure

The procedures for data collection of this research include reviewing literatures and collecting secondary data. Robinson & Reed (1998) defined a literature review as a systematic search of published work to find out what is already known about the intended research topic. Aitchison (1998) supported the view that a literature review allows the researcher to find out what has been done in terms of problem being investigated to ensure that duplication doesn’t occur. Sugiyono (2007) and Gujarati (1999) suggested that secondary data collected from published report issued by government or institution should meet data adequacy requirements in order to be accountable.

3.4 Analysis Method

Based on research problem and objectives, the analysis uses econometric method. This method combines economic theory and statistical analysis to forecast energy demand by establishing the relationship between energy consumption and its influencing factors. When combined with end-use approach, the behavioural components are added to the end-use equations for more accurate forecasting and understanding of energy consumption. Econometric method is suitable for long-term forecasting and simulation of different demand scenarios, technology implementations, policy adoptions, and consumers’ behavioural changes.

There are three steps of analysis method used, i.e. estimation, forecasting, and simulation. This research uses Eviews 4.0 and Microsoft Office Excel as data processors. Stages of the analysis method will be discussed in sub section 3.4.1 to 3.4.3.

3.4.1 Estimation

As described in section 2.1.4, the model of this study will be estimated using simultaneous equation model to analyze the factors affecting energy supply and demand based on energy balance model. Simultaneous equations are models in which two or more equations share two or more variables linking the equations together in a system. Thus, the endogenous variable of one equation may appear as an explanatory variable of other equation in the system.

3.4.1.1 Model Identification

Prior to estimating, equations were identified to find out the proper estimation method for the model, as suggested by Koutsoyiannis (1977). The identification means that the parameters' numerical estimates of the structural equation can be obtained from the estimated reduced-form coefficients. If this condition had been met, then the simultaneous equation can be solved. The identification should be done because the same set of data may result in structural coefficients from different model and hypothesis.

Order condition and rank condition were criterias being used to identify the equation so that unique values of structural parameter could be derived from the reduced form of the system. Order condition is a necessary but not sufficient condition for identification. A structural equation in simultaneous equations' system has general principles of identifiability as follows (Koutsoyiannis, 1977):

Underidentified : $(K\text{-}M) < (G\text{-}1)$

Exactly identified : $(K\text{-}M) = (G\text{-}1)$

Overidentified : $(K\text{-}M) > (G\text{-}1)$

Note:

K = number of predetermined and endogenous variables in the model

M = number of predetermined variables in a given equation

G = number of endogenous variables in a given equation

In this research, the energy balance model is divided into 4 blocks comprised of 48 equations consisting of 26 structural equations and 22 identity equations. The structural equation comprised of 26 endogenous variables (G) and 28 predetermined variables (M), so the total variable in the model (K) are 54 variables. Thus, based on order condition criteria, the equation of the energy balance model is overidentified.

3.4.1.2 Estimation Method

After simultaneous equation had been identified, the next step is to estimate the model. For an exactly identified structural equation, the method for obtaining the estimation of the model is indirect least square (ILS), while the identified or overidentified equations will be using two-stage least squares (2SLS).

a. *Indirect Least Square* (ILS)

Indirect Least Square method can be applied appropriately for the estimation of an equation in a system of simultaneous equations. The name ILS is derived from the fact that the structural coefficients are obtained indirectly from the ordinary least square (OLS) estimation of the reduced-form coefficients. These reduced-form equations are obtained from the structural equations in such manner that the dependent variable in each equation is the only endogenous variable and is a function solely of the predetermined (exogenous or lagged endogenous) variables and the stochastic error terms. Thus, the method of ILS is only suited for exactly identified coefficient. In this method, OLS is applied to the reduced-form equation, and it is from the reduced-form coefficients that on estimates the original stuctural coefficients.

b. *Two Stage Least Square* (*2SLS*)

The method of 2SLS is an individual equation in the system by the existence of correlation between exogenous variables, thus OLS technique is applied separately to each structural equations in order to avoid simultaneous equation bias. Therefore, it is said theoretically that 2SLS method is an extension of ILS method. Interdependency between exogenous and stochastic variables on ILS was eliminated by applying OLS to the reduced-form equation, while the basic idea behind 2SLS is to replace the (stochastic) endogenous explanatory variable with a linear combination of the predetermined variables in the model and use this combination as the explanatory variable in lieu of the original endogenous variable. The 2SLS method thus resembles the instrument variable method of estimation in that the linear combination of the predetermined variables serving as instrument or proxy for the endogenous regressor.

As this two-stage procedure indicated, the first procedure is to estimate the reduced-form regression of Y_1 in all predetermined variables in the system by using OLS. Reduced-form structural equation is derived from mathematical manipulation of endogenous variable, regressed with endogenous variable. The second step obtains the estimated Y_1 and replaces Y_{1t} in the original equation by the estimated Y_{1t}. The use of OLS in the second step will yield a consistent estimator.

The 2SLS method is used for the reason:

a. In overidentified equation, 2SLS provides a single estimation value for each parameter, while ILS provides multiple estimations.
b. The 2SLS has no difficulties to estimate standard error from their reduced-form coefficients because the structural coefficients are directly estimated from the second stage of OLS regression, when ILS does not provide the same convenience (Gujarati, 1995).

3.4.1.3 The t-test and F-test

The theory of hypothesis testing is concerned with procedures development for deciding whether to reject or not reject the null hypothesis using the approach of confidence interval and test of significance. After determining confidence coefficient of 90 to 95 percent or the significance level of 5 to 10 percent, compare the test statistic's value (t-test and F-test) obtained using *Eviews 4* statistical package program. Or else, compare the actual probability (P-value) of the obtained value of the test statistic with statistical table.

In a multiple regression, t-test is used to test the individual significance of a partial regression while F-test is used to assess the significance of parameter variable regression collectively (Koutsoyiannis, 1977).

Hypothesis of the F-test:

$H_0: \beta_1 = \beta_2 \ldots\ldots = \beta_i = 0$

H_1: not all slope coefficients are simultaneously zero $\beta_i \neq 0$

Note:

i = number of explanatory variable in a model

If using conventional significance level (α) of 5 percent and P-value of F-test is less than α, then reject H_0. Rejected H_0 means that all explanatory variables have significance for the endogenous variable.

Hypothesis of the t-test:

H_0: $\beta_1 = 0$

H_1: one tailed test

a) $\beta_1 > 0$;

b) $\beta_1 < 0$

H_1: two tailed test

c) $\beta_1 \neq 0$

Critical region:

If H_1: a) $\beta_1 > 0$, if P-value of t-test < α, reject H_0

H_1: b) $\beta_1 < 0$, if P-value of t-test < α, reject H_0

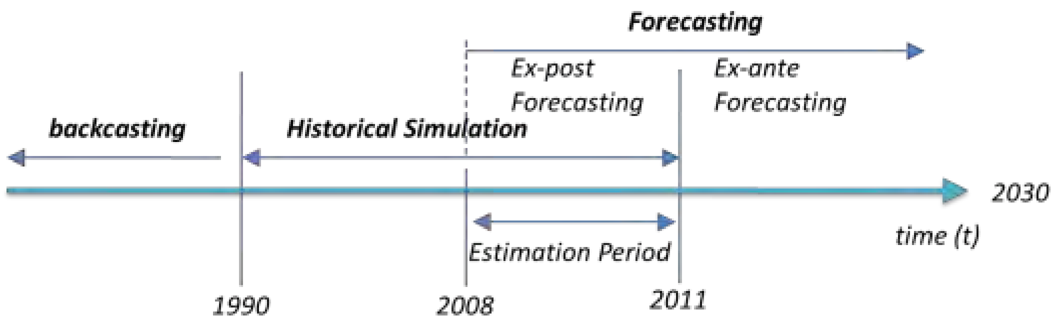
H_1: c) $\beta_1 \neq 0$ if P-value of t-test < $\alpha/2$, reject H_0

Rejected H_0 means that an explanatory variable has significant correlation with endogenous variable.

3.4.2 Forecasting and Validation

Once the model has coefficient estimation and is statistically significant, the model can be used for forecasting and simulating. Time horizon-based forecast can be divided into ex post forecasting, ex ante forecasting, and backcasting, as shown on Figure 3.1. This research, the time bounds over which the equations of hypothetical model which estimated based on historical data from 1990 to 2011. In an ex post forecast for period 2008 to 2011, observation on both endogenous and exogenous explanatory variables are already known during the forecast period. Thus, ex post forecast can be checked against existing data while providing a means of evaluating a forecast model. An ex ante forecast beginning in 2012 also predicted values of the dependent variable beyond the original estimation period.

Figure 3.1 Simulation Time Horizons



Source: Pindyck and Rubinfield, 1998

This forecast uses stepwise autoregression (STEPAR) method, which is a combination of time trend model with autoregressive model. Stepwise autoregression begins with generating the estimation of exogenous explanatory variables using trend linear model, followed by estimating endogenous variables using the previous energy balance model.

Model Validation

Energy balance model created in historical and ex post forecast period are validated to determine how well the models performed based on available data for forecasting and simulating. Model validation is used for quantitatively comparing the estimated model to the actual data. The ideal model will be able to provide an accurate estimation value of observation value resulting zero error. There are several forecast performance measures to assess model accuracy, i.e. Root Mean Square Error (RMSE), Root Mean Square Percent Error (RMSPE), Mean Absolute Error (MAE), Mean Absolute Percent Error (MAPE) and U-Theil's (Theil's Inequality Coefficient). These criterias are defined as follows (Pindyck and Rubinfeld, 1998):

$$RMSE = \sqrt{\left(1/n\right) * \sum_{n=1}^{n}(P_i - A_i)^2} \quad \text{.......... (3.1)}$$

$$RMSPE = 100 * \sqrt{\left(1/n\right) * \sum_{i=1}^{n}\left(\frac{P_i - A_i}{A_i}\right)^2} \quad \text{.......... (3.2)}$$

$$MAE = \frac{\sum_{i=1}^{n}|P_i - A_i|}{n} \quad \text{.......... (3.3)}$$

$$MAPE = 100 * \frac{\sum_{i=1}^{n}\left|\frac{P_i - A_i}{A_i}\right|}{n} \quad \text{.......... (3.4)}$$

$$U = \frac{\sqrt{(1/n) * \sum(P_i - A_i)}}{\sqrt{(1/n) * \sum(P_i)^2 + \sqrt{(1/n) * \sum A_i^2}}} \quad \text{.......... (3.5)}$$

Note:

n = number of observation

Pi = predicted value

Ai = actual value

RMSE, RMSPE, MAE, and MAPE are used to measure the deviation of the simulated endogenous variable from the actual data or how close the forecasted variable tracks the actual data. The smaller the resulted forecast error indicates the more reliable the prediction of the model will be. RMSE and MAE depend on the unit of measurement used.

In addition, bias proportion (UB), variance proportion (UV), covariance proportion (UC), and Theil's inequality coefficient (U) are used to evaluate the model's ability to simulate. Theil's coefficient value is ranged between 0 and 1. The smaller value of Theil's coefficient (closer to zero), the better model's performance to predict. Conversely, if the U value is greater (close to 1), then the model has projected value that is systematically different from the actual data.

A large value of bias proportion (UB), i.e. above 0.1 or 0.2 indicates a systematic bias, so the revision of the model will be necessary (Pindyck dan Rubinfield, 1998). Moreover, if varians proportion (UV) is large, it means that the actual series has fluctuated considerably compared to the simulated series. In other words, the model has not been able to replicate the fluctuation pattern and might lead to revision of the model. Finally, the ideal model will have the covariance proportion (UC) close to 1.

Coefficient of determination (R^2) is used to evaluate the correlation coefficient between the simulated and the actual series. Basically, small value of RMSE, RMSPE, MAE, MAPE, U-Theil's with large value of R^2 will provide a better performance of simulation model.

3.4.3 Simulation

The aim of policy simulation is to analyze the effect of various policy alternatives by changing the policy's parameter value (Pindyck dan Rubinfield, 1998). A model simulation is conducted to see how the changing exogenous policy variables affect the energy demand until 2030. This research will simulate eight policy alternatives on energy and oil import demand:

1. Baseline scenario, with assumptions:
    - Projection of population growth until 2025 refers to BPS' published report and for the period 2026 to 2030 projection follows the long-term linear trend on Table B-1 Appendix B
    - Indonesia's economic structure is assumed to be fixed through 2030, still depends on production sector (primary and secondary)
    - Production of crude oil, natural gas, coal, geothermal, and hydropower follows Indonesia Energy Outlook 2010 from Ministry of Energy and Mineral Resources, Table B-2 Appendix B
    - World oil price reflects the information from U.S Annual Energy Outlook 2013, IEA
    - Other domestic energy prices also reflect the information from Indonesia Energy Outlook 2010 (ESDM), Table B.4 Appendix B
    - Addition of new oil refineries refers to the data from Indonesia Energy Outlook 2010 (KESDM, 2010), Table B.3 Appendix B
2. Scenario of increasing rate of GDP

3. Scenario of the increase in subsidized fuel's price in every 4 years through subsidy budget reduction
4. Scenario of the increase in world oil price
5. Scenario of the increase in crude oil production, based on government policy for increasing oil and gas production in 2014 (President Instruction No.2/2012)
6. Scenario of the increase in refinery efficiency, based on government policy for adding oil refinery and increasing efficiency
7. Scenario of energy diversification from gasoline to Natural Gas Vehicle (NGV) at transportation sector and from gasoline to geothermal for electrical power sector, as per Energy Law No.30/2007
8. Simultaneous scenario, i.e. the combination of all scenario to reduce oil dependence such as increasing subsidy fuel price, increasing crude oil production and refinery efficiency, energy diversification from gasoline to natural gas and geothermal.

3.5 Model

Based on conceptual framework and hypotheses in the previous section, research model was built based on theories and previous researches. This sub section will discuss model structure, definition, and measurement of operational variable.

3.5.1 Model Structure

Model structure is the first and the most important step for starting the study of relationship among variables. The model is used to represent relationship among variables mathematically whereas economic phenomenon can be studied empirically (Koutsoyiannis, 1997).

The key to projecting energy balance is to tie its components firmly to underlay economic developments and to spell out the structure of the internal linkages that make up the balance. Those relationships and modification of energy balance model on Figure 2.5 are summarized in diagram in Figure 3.2 that shows five energy sources used in Indonesia's energy balance model analysis.

1. It begins with estimating total sectoral energy demand for secondary or directly utilized primary energy. Secondary energy such as petroleum products, gas, LPG, and electricity are used by industry, transportation, residential, commercial, and other sectors. Primary energy such as gas, biomass, coal, geothermal, and hydropower is also utilized by power generation sector to generate electricity. The total sectoral fuel demand represents the secondary energy requirement by fuel. The total secondary energy demand is allocated to individual model split equations.
2. Demands for secondary fuels are allocated to the transformation process in order to generate primary energy requirement confronted with domestic energy production and import. Assuming that sufficient generating capacity is available, the consumption of electrical power is not constrained by capacity, so currently there is no electrical import. Crude oil input for refining is

determined by the availability and specification of refinery capacity. Refinery output is determined by crude oil input and a refinery loss parameter.

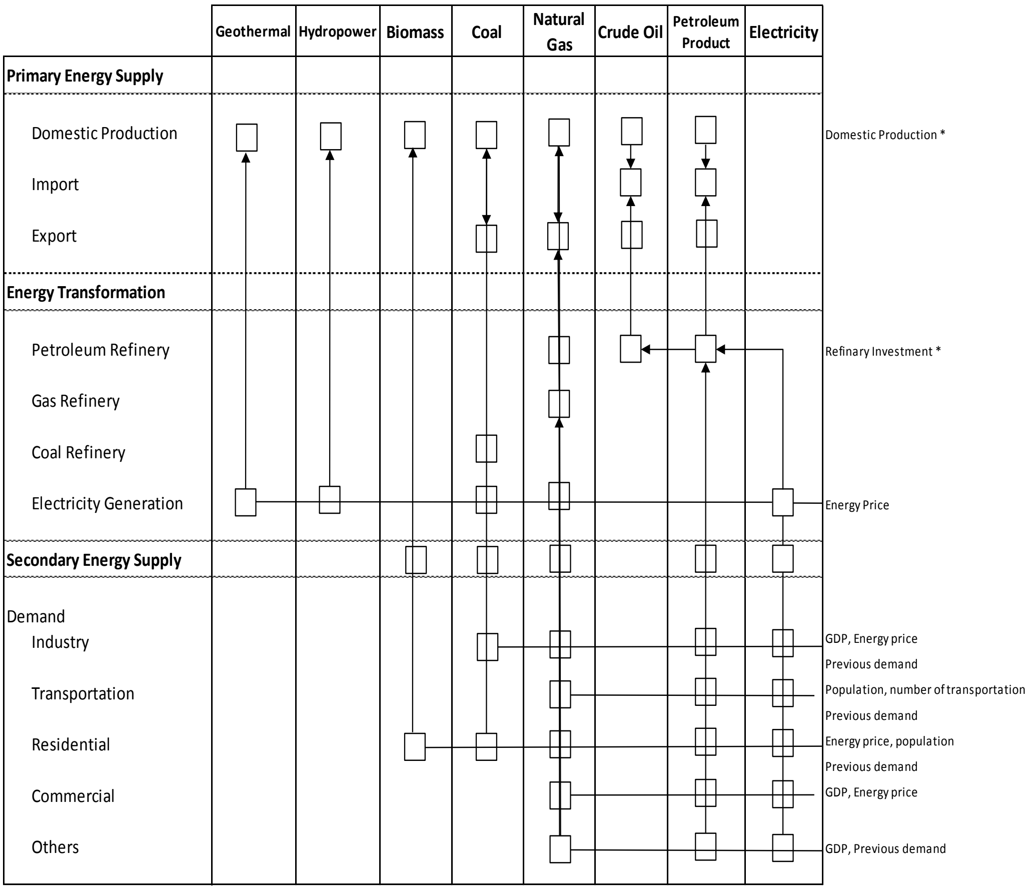
3. On the top of the diagram, primary energy supply includes domestic production, imports and exports. Domestic production is projected on the basis of present and projected supply availability of crude oil and petroleum product from domestic sources. Domestic crude oil production is calculated as a share of government split from production sharing contract (PSC). Oil export includes crude oil from government and contractor's shares, and non petroleum product. Import requirements of crude oil and petroleum products, which are the target of the analysis, are computed as the difference between domestic needs (plus exports) and domestic production.

3.5.1.1 Model Structure of Energy Consumption Block

The model structure of energy consumption is computed as linkages from economic activity to sectoral energy demand. Energy consumption block includes petroleum products, gas, coal, geothermal, and hydropower demand in electricity generation, industry, residential, transportation, commercial, and other sectors.

Sectoral energy demand per type of energy is determined using equation (2-36), stating that energy demand is influenced by price of the energy itself, price of other energy (substitute or complement), GDP, and lagged consumption variables.

Figure 3.2 Energy Balance Model Diagram



Source: Adams *et al*., (2000), modified

A. Oil Fuel Consumption

Petroleum products resulted from crude oil transformation are used for many purposes: (1) gasoline and diesel fuel for electricity generation, transportation, industrial, and other sectors, (2) kerosene fuel for cooking and lighting in residential and commercial sector, and (3) petroleum product as a feedstock for industrial sector.

Oil consumption as a fuel is determined by price of oil fuel and other energy such as coal, gas and electricity, number of population and household, number of vehicle, total GDP, GDP sectoral, diversification ratio, and lagged petroleum product consumption. The following equation model for oil fuel consumption with the explanation of variables is shown in Table C-1 Appendix C:

a. Consumption of Oil Fuel in Electricity Generation Sector (*EGOLt*)

$EGOLt = a_1 + a_2*RPOILDt + a_3*RPCOALt + a_4*RPGASIt + a_5*EGGt + a_6*JRt + a_7*EGOLt(-1) + U_1$ .... (3.6)

b. Consumption of Oil Fuel in Industrial Sector (*IDOLt*)

$IDOLt = b_1 + b_2*RPOILDt + b_3*RPGASIt + b_4*RPELIt + b_5*RPCOALt + b_6*PDBt + b_7*OGR\_IN + b_8*IDOLt(-1) + U_2$ .... (3.7)

c. Consumption of Oil Fuel in Residential Sector (*REOLt*)

$REOLt = c_1 + c_2*RPOILMTt + c_3*RPGASLt + c_4*OGR + c_5*PDBt/POPt + c_6*JRt + c_7*REOLt(-1) + U_3$ .... (3.8)

d. Consumption of Oil Fuel in Transport Sector (*TROLt*)

$TROLt = d_1 + d_2*RPOILPT + d_3*RPGASIt + d_4*VEHI + d_5*PDBt/POPt + d_6*TRRTGt + d_7*TROLt(-1) + U_4$ .... (3.9)

e. Consumption of Oil Fuel in Commercial Sector (*COMOLt*)

$COMOLt = e_1 + e_2*RPOILMTt + e_3*RPGASLt + e_4*RPELIt + e_5*PDBt + e_6*COMOLt(-1) + U_5$ .... (3.10)

f. Consumption of Oil Fuel in Other Sector (*OCOLt*)

$OCOLt = f_1 + f_2*RPOILSt + f_3*SKBRt + f_5*OCPt + f_6*OCOLt(-1) + U_6$ .... (3.11)

g. Total Oil Fuel Consumption (*FCOLt*)

$FCOLt = EGOLt + IDOLt + REOLt + TROLt + COMOLt + OCOLt$ .... (3.12)

Note:

EGOLt(-1) = lagged consumption of oil fuel in electricity generation sector

IDOLt(-1) = lagged consumption of oil fuel in industrial sector

REOLt(-1) = lagged consumption of oil fuel in residential sector

TROLt(-1) = lagged consumption of oil fuel in transport sector

COMOLt(-1) = lagged consumption of oil fuel in commercial sector

OCOLt(-1) = lagged consumption of oil fuel in other sector

B. Gas Consumption

Gas is consumed by electricity generation, industrial, residential, transport and commercial sector in the form of natural gas, city gas, and LPG. Gas consumption is determined by technical aspects, such as location of gas supply, pipeline infrastructure and converter, also economic aspects like gas price, other energy price (coal, oil, and electricity), number of population and residential, growth of sectoral GDP, and lagged gas consumption variable.

Aside from being used as gas fuel, natural gas also used as a feedstock in chemical and fertilizer industries. Domestic gas consumption is now starting to grow in line with government policies to reduce oil dependency. The following equation model for gas consumption with the explanation of variables is shown in Table C-1 Appendix C:

a. Consumption of Gas in Electricity Generation Sector (*EGGt*)

$$EGGt = g_1 + g_2*RPOILSt + g_3*RPCOALt + g_4*RPGASIt + g_5*(1-OGR\_EG) + g_6*JRT + g_7*PDBt + g_8*EGGt(-1) + U_8 \quad (3.13)$$

b. Consumption of Gas in Industrial Sector (*IDGt*)

$$IDGt = h_1 + h_2*RPOILSt + h_3*RPGASIt + h_4*RPELIt + h_5*RPCOALt + h_6*INDPt + h_7*POPt + h_8*IDGt(-1) + U_9 \quad (3.14)$$

c. Consumption of Gas in Residential Sector (*REGt*)

$$REGt = i_1 + i_2 * RPGASLt + i_3 * PDB/POPt + i_4 * REOLt + i_5 * REGt(-1) + U_{10} \quad \ldots (3.15)$$

d. Consumption of Gas in Transpor Sector (*TRRTGt*)

$$TRRTGt = j_1 + j_2 * RPOILPT + j_3 * RPGASIt + j_4 * PDBt/POPt + j_5 * TRRTGt(-1) + U_{11} \quad \ldots (3.16)$$

e. Consumption of Gas in Commercial Sector (*COMGt*)

$$COMGt = k_1 + k_2 * RPOILMTt + k_3 * RPGASLt + k_4 * (1\text{-}OGR\_COM) + k_5 * COMPt + k_6 * COMGt(-1) + U_{12} \quad \ldots (3.17)$$

f. Total Gas Consumption (*ECGt*)

$$ECGt = EGGt + IDGt + REGt + TRRTGt + COMGt \quad \ldots (3.18)$$

Note:

EGGt(-1) = lagged consumption of gas in electricity generation sector

IDGt(-1) = lagged consumption of gas in industrial sector

REGt(-1) = lagged consumption of gas in residential sector

TRRTGt(-1) = lagged consumption of gas in transport sector

COMGt(-1) = lagged consumption of gas in commercial sector

C. Coal Consumption

Coal is a solid energy that is commonly consumed by electricity generation and industrial sector, while residential only uses it in small amount as thermal energy for cooking. Coal consumption is determined by coal price, other energy price (oil, gas and electricity), number of population and residential, growth of sectoral GDP, and lagged coal consumption variable. Increasing consumption of coal for domestic needs has begun in line with government policies to reduce oil dependency and reduce coal export. The following equation model for coal consumption with the explanation of variables is shown in Table C-1 Appendix C:

a. Consumption of Coal for Electricity Generation Sector (*EGCLt*)

$EGCLt = l_1 + l_2*RPOILDt + l_3*RPCOALt + l_4*POPt + l_5*EGPt + l_6*EGCLt(-1) + U_{13}$ .... (3.19)

b. Consumption of Coal for Industrial Sector (*IDCLt*)

$IDCLt = m_1 + m_2*RPOILSt + m_3*RPCOALt + m_4*INDPt + m_5*IDCLt(-1) + U_{14}$ .... (3.20)

c. Consumption of Coal for Residential Sector (*RECLt*)

$RECLt = n_1 + n_2* RPCOALt + n_3*POPt + n_4*RECLt(-1) + U_{15}$ .... (3.21)

d. Total Coal Consumption (*FCCLt*)

$FCCLt = EGCLt + IDCLt + RECLt$ .... (3.22)

Note:

EGCLt(-1) = lagged consumption of coal in electricity generation sector

IDCLt(-1) = lagged consumption of coal in industrial sector

RECLt(-1) = lagged consumption of coal in residential sector

D. Electricity Consumption

Electricity is used in three main consumers: industrial, residential, and commercial sector. Transport sector uses electric train in very small amount, thus doesn’t have significant effect in this research. Electricity consumption continues to grow along with the increase of purchasing power and lifestyle for clean energy.

Electricity consumption is determined by electricity price, other energy price (oil, gas and coal), number of population and household, growth of sectoral GDP, and lagged electricity consumption variable. The following equation model for electricity consumption with the explanation of variables is shown in Table C-1 Appendix C:

a. Consumption of Electricity in Industrial Sector (*IDEGt*)

$IDEGt = o_1 + o_2*RPOILSt + o_3*RPGASIt + o_4*RPELIt + o_5*INDPt + o_6*IDEGt(-1) + U_{16}$ .... (3.23)

b. Consumption of Electricity in Residential Sector (*REEGt*)

$REEGt = p_1 + p_2* RPELRt + p_3*POPt + p_4*PDBt/POPt + p_5*REEGt(-1) + U_{17}$ .... (3.24)

c. Consumption of Electricity in Commercial Sector (*COMEGt*)

$COMEGt= q_1 + q_2*RPELKt + q_3*COMPt + q_4*COMEGt(-1) + U_{18}$ ..... (3.25)

d. Total Electricity Consumption

ECEGt = IDEGt + REEGt + COMEGt .... (3.26)

Note:

IDEGt(-1) = lagged consumption of electricity in industrial sector

REEGt(-1) = lagged consumption of electricity in residential sector

COMEGt(-1) = lagged consumption of electricity in commercial sector

E. Biomass Consumption

Biomass in the form of firewood is still widely used by rural households for cooking purposes. In the future, biomass consumption will decrease due to the modernization of energy use (LPG and electricity) as well as concern for the environment and forest conservation. Thus, biomass consumption in residential sector (*REBIOt*) will be affected by the price of kerosene (*RPOILMTt*) and previous biomass consumption (*REBIOt(-1)*). Equation model for biomass consumption is:

REBIOt = $r_1 + r_2$*RPOILMTT + r_3*JRT + r_4*REBIOt(-1) + U_{19} .... (3.27)

Note:

REBIOt(-1) = lagged consumption of biommas in residential sector

F. Geothermal and Hydropower Consumption

Geothermal and hydropower is used for energy sources of Geothermal Electricity Generation (PLTP) and Hydroelectricity Generation (PLTP). This renewable energy consumption is greatly influenced by its resource, the location of energy supplies, and energy prices. Equation model of geothermal and hydropower consumptions are:

EGGTt = $s_1 + s_2$*RPGTt + s_3*IPGTt + U_{20} .... (3.28)

EGHYt = $t_1 + t_2$*RPHYt + t_3*IPHYTt + U_{21} .... (3.29)

Note:

RPGTt = price of geothermal

RPHYTt = price of hydropower

IPGTt(-1) = production of geothermal

IPHYTt(-1) = production of hydropower

3.5.1.2 Model Structure of Transformation Block

Energy transformation is a process of energy change from primary energy source (coal, crude oil, natural gas, etc.) to secondary or final energy used to be consumed. In this research, transformation block will only discuss equation of petroleum refinery.

Petroleum refinery is a transformation process from crude oil to petroleum product such as gasoline, kerosene, aviation fuel, diesel, pertamax, LPG, lube base oil, petrochemical, naptha, asphalt, and low sulfur waxy residue. Petroleum refinery is affected by growth on crude oil or refinery capacities (*RFCRt*) and refinery efficiency or utilization (*RFUTt*). The equation model for petroleum refinery or transformation process (*OTPPt*) is as follows:

OTPPt = RFCRt * (1-RFUTt) .... (3.30)

3.5.1.3 Model Structure of Energy Supply Block

The requirements of energy supply are allocated from the differences between domestic production, import, and export. The energy supply block includes crude oil production, refinery utilization, crude oil input for refinery, refined petroleum product, crude oil import, petroleum product import, total oil import, and total energy supply.

A. Refinery Utilization

Petroleum refinery utilization is a refinery capability to produce petroleum product determined by ratio of refinery input and output.

B. Crude Oil Input for Refinery

Crude oil input for refinery (*RFCRt*) is determined by refinery utilization (*RCCRt*) and capacity (*RFCICRt*). The equation of crude oil input for refinery is:

RFCRt = RCCRt * RFCICRt .... (3.31)

C. Domestic Petroleum Product

Domestic petroleum product is resulted from crude oil transformation at petroleum refinery which consists of oil fuel and non oil fuel. The equation of oil fuel production (*YBBMt*) is:

YBBMt = OTPPt * OTPPRt .... (3.32)

Note:

OTPPRt = refinery product ratio (oil fuel and non oil fuel)

Non oil fuel production (*YNBBMt*) will be calculated as an identity equation as follows:

YNBBMt = OTPPt – YBBMt .... (3.33)

D. Oil Supply

Indonesia'a oil supply includes crude oil and oil fuel supply. Referring to equation (2-3), oil supply is calculated as the differences between production and import with export and stock.

The supply of crude oil is limited to domestic crude oil refining capacity (*RFCRt*). Crude oil supply (*SCRt*) is calculated as the differences between domestic crude oil production (*IPOLt*) and crude oil import (*IMCRt*) with its export (*EXOLt*) and stock (*CRBLNCt*), as shown on this equation:

SCRt = RFCRt = IPOLt + IMCRt – EXOLt – CRBLNCt .... (3.34)

As for the supply of oil fuel, it comes from the differences between oil fuel production (*YBBMt*) and oil fuel import (*IMPPt*) with its export and stock (*PPBLNCt*). Oil fuel export comes with insignificant amount and will be excluded from this research. The equation of oil fuel supply is:

SBBMt = FCOLt = YBBMt + IMPPt– PPBLNCt .... (3.35)

Total oil import is calculated as a sum of crude oil and oil fuel import, as shown on the equation below:

IMOLt = IMCRt + IMPPt .... (3.36)

Other energy on supply block consists of natural gas, coal, biomass, geothermal, and hydropower. Geothermal and hydropower are used mainly to generate electricity, thus the development depend on their location and the economic price. Result of gas refinery, including LPG and LNG, are widely used for export demand, as well as coal. So, the use of natural gas for domestic needs is adapted to the existing gas sales contracts. Biomass is widely used by residential sector in the form of firewood and charcoal.

3.5.1.4 Model Structure of Economic Output Block

This study starts from the general hypothesis stating that the country's economic growth will affect the energy supply and demand. GDP will affect energy demand through sectoral GDP. Thus, this study formulates that GDP affects energy supply and demand both directly and indirectly.

In general, the output or national production function is formulated using the equation (2-15). In this study, sectoral GDP is affected by international oil price (*POILWDt*), interest rate (*SKBRt*), exchange rate (*EXCHt*), population (*POPt*), and lagged sectoral GDP. GDP equation model for electricity generation, industrial, transport, commercial, and other sectors are shown below with the explanation of variable shown in Table C-1 Appendix C:

a. GDP in Electricity Generation Sector (*EGPt*)

$EGPt = w_1 + w_2*SKBRt + w_3*EGPt(-1) + U_{24}$ .... (3.37)

b. GDP in Industrial Sector (*INDPt*)

$INDPt = x_1+ x_2*SKBRt + x_3*INDPt(-1) + U_{24}$ .... (3.38)

c. GDP in Transport Sector (*TRPt*)

$TRPt = y_1 + y_2*SKBRt + y_3*PDBt + y_5*TRPt(-1) + U_{25}$ .... (3.39)

d. GDP in Commercial Sector (*COMPt*)

$COMPt = z_1 + z_2*SKBRT + z_3*COMPt(-1) + U_{26}$ .... (3.40)

e. GDP in Other Sector (*OCPt*)

$OCPt = aa_1 + aa_2*SKBRt + aa_3*EXCHt + aa_4*OCPt(-1) + U_{27}$............... (3.41)

f. Total GDP (*PDBt*)

$PDBt = EGPt + INDPt +TRPt + COMPt + OCPt$ .... (3.42)

Note:

EGPt(-1) = lagged GDP in electricity generation sector

INDPt(-1) = lagged GDP in industrial sector

TRPt(-1) = lagged GDP in transport sector

COMPt(-1) = lagged GDP in commercial sector

OCPt(-1) = lagged GDP in other sector

3.5.2 Definition and Operational Variable Measurement

Referring to the previous model structure, there are 48 equations consisting 26 structural equations and 22 identity equations. This structural model consists of 26 endogenous variables and 28 predetermined variables. Definition and measurement of the equations are shown in Table 3.1:

Table 3.1 Definition and Measurement of Operational Variables

No	Name of Variable	Definition	Measurement	Data Source
1	Total Final Energy Consumption (ECT) ***(Identity)***	Total final energy demand is the sum of energy consumption in each final demand sector. At least eight types of energy are shown: oil fuel, natural gas, LPG, electricity, coal, biomass, geothermal, and hydropower. There are at least six sectors of energy user: residential, industrial, electricity generation, transportation, commercial, and other sector.	Total final energy consumption in Barrel of Oil Equivalent (BOE) ECT = FCOLt + ECGt + FCCLt + ECEGt + REBIOt + EGGTt + EGHYt ..(3.43)	Ministry of Energy and Natural Resources (2013)
2	Oil Fuel Consumption (FCOLt) ***(Identity)***	Total oil fuel demand is the sum of oil fuel consumption in each final demand sector. At least five types of oil fuel are shown: kerosene, solar, diesel, gasoline and pertamax that are consumed by six sectors of energy user, such as residential, industrial, electricity	Total oil fuel consumption in Barrel of Oil Equivalent (BOE) FCOLt = EGOLt + IDOLt + REOLt +TROLt + COMOLt + OCOLt ..(3.12)	Ministry of Energy and Natural Resources (2013)

No	Name of Variable	Definition	Measurement	Data Source
		generation, transportation, commercial, and other sector.		
3	Gas Consumption (ECGt) ***(Identity)***	Total gas demand is the sum of gas consumption in each final demand sector. At least five types of gas are shown: natural gas, gas pipe, LPG, and LNG consumed by five sectors of energy user, such as residential, industrial, electricity generation, transport and commercial sector.	Total gas consumption in Barrel of Oil Equivalent (BOE) ECGt = EGGt + IDGt + REGt +TRRTGt + COMGt .... (3.18)	Ministry of Energy and Natural Resources (2013)
4	Coal Consumption (FCCLt) ***(Identity)***	Total coal demand is the sum of coal consumption in each final demand sector. At least two types of coal are shown: coal and bricket consumed by three sectors of energy user, such as residential, industrial, and electricity generation sector	Total coal consumption in Barrel of Oil Equivalent (BOE) FCCLt = EGCLt + IDCLt + RECLt .... (3.22)	Ministry of Energy and Natural Resources (2013)
5	Electricity Consumption (ECEGt) ***(Identity)***	Total electricity demand is the sum of electricity consumption in each final demand sector. At least there are three sectors of energy user, such as residential, industrial, and commercial sector	Total electricity consumption in Barrel of Oil Equivalent (BOE) ECEGt = IDEGt + REEGt + COMEGt .... (3.26)	Ministry of Energy and Natural Resources (2013)

No	Name of Variable	Definition	Measurement	Data Source
6	Biomass Consumption (REBIOt)	Firewood demand in residential sector	Biomass consumption in Barrel of Oil Equivalent (BOE) REBIOt = r1 + r2*RPOILMTT + r3*REBIOt(-1) + U19 .... (3.27)	Ministry of Energy and Natural Resources (2013)
7	Geothermal Consumption (EGGTt)	Geothermal energy consumption to generate electricity from electricity generation sector	Geothermal demand in Barrel of Oil Equivalent (BOE) EGGTt = s1 + s2*RPGTt + s3*IPGTt + U20 ...... (3.28)	Ministry of Energy and Natural Resources (2013)
8	Hydropower Consumption (EGHYTt)	Potential energy from hydropower; calculated as energy input to generate electricity from dams, watershed, and microhydro	Hydropower demand in Barrel of Oil Equivalent (BOE) EGHYt = t1 + t2*RPHYt + t3*IPHYTt + U21 .... (3.29)	Ministry of Energy and Natural Resources (2013)
9	Consumption of Oil Fuel for Electricity Generation (EGOLt)	The use of oil fuel, such as fuel oil, and diesel by electricity generation sector.	Oil fuel demand for electricity generation in Barrel of Oil Equivalent (BOE) EGOLt = a1 + a2*RPOILSt +a3*RPCOALt+a4*RPGASIt + a5*OGR_EG + a6*POPt + a7*EGOLt(-1)+U1 .... (3.6)	Ministry of Energy and Natural Resources (2013)
10	Consumption of Oil Fuel for Industrial Sector (IDOLt)	The use of oil fuel such as diesel, fuel oil, and kerosene by industrial sector	Oil fuel demand for industrial sector in Barrel of Oil Equivalent (BOE) IDOLt = b1+ b2*RPOILDt + b3*RPGASIt +b4*RPELIt + b5*RPCOALt + b6*PDBt + b7*IDOLt(-1) + U2 .... (3.7)	Ministry of Energy and Natural Resources (2013)
11	Consumption of Oil Fuel in Residential Sector (REOLt)	The use of kerosene for residential sector	Oil fuel demand for residential sector in Barrel of Oil Equivalent (BOE) REOLt = c1 + c2*RPOILMTt +	Ministry of Energy and Natural Resources (2013)

No	Name of Variable	Definition	Measurement	Data Source
			c3*RPGASLt + c4*OGR + c5*PPKt + c6*REOLt(-1) + U3 .... (3.8)	
12	Consumption of Oil Fuel in Transport Sector (TROLt)	The use of gasoline, diesel, pertamax, and aviation fuel by transportation sector	Oil fuel demand for Transport sector in Barrel of Oil Equivalent (BOE) TROLt = d1 + d2*RPOILPT + d3*RPGASIt + d4*VEHI + d5*PDBt + d6*TROLt(-1) + U4 .... (3.9)	Ministry of Energy and Natural Resources (2013)
13	Consumption of Oil Fuel in Commercial Sector (COMOLt)	The use of diesel and kerosene by commercial sector	Oil fuel demand for commercial sector in Barrel of Oil Equivalent (BOE) COMOLt = e1 + e2*RPOILMTt + e3*RPGASLt+ e4*RPELKt+ e5*COMPt + e6*COMOLt(-1) + U5 .... (3.10)	Ministry of Energy and Natural Resources (2013)
14	Consumption of Oil Fuel in Other Sector (OCOLt)	The use fuel oil, diesel and kerosene by other sector	Oil fuel demand for other sector in Barrel of Oil Equivalent (BOE) OCOLt = f1 + f2*RPOILSt + f3*RPGASLt + f5*OCPt+ f6*OCOLt(-1) + U6 .... (3.11)	Ministry of Energy and Natural Resources (2013)
15	Consumption of Gas in Electricity Generation Sector (EGGt)	The use of gas fuel to generate electricity	Gas demand for electricity generation sector in Barrel of Oil Equivalent (BOE) EGGt = g1 + g2*RPOILSt + g3*RPCOALt + g4*RPGASIt + g5*(1-OGR_EG) + g6*JRT + g7*PDBt + g8*EGGt(-1) + U8 .... (3.13)	Ministry of Energy and Natural Resources
16	Consumption of Gas in Industrial Sector (IDGt)	The use of natural gas, LPG, and LNG in industrial sector as fuel and feedstock.	Gas demand for industrial sector in Barrel of Oil Equivalent (BOE) IDGt = h1 + h2*RPOILSt + h3*RPGASIt + h4*RPELIt + h5*RPCOALt + h6*INDPt + h7*POPt +	Ministry of Energy and Natural Resources (2013)

No	Name of Variable	Definition	Measurement	Data Source
			h8*IDGt(-1) + U9 .... (3.14)	
17	Consumption of Gas in Residential Sector (REGt)	The use of natural gas (city gas) and LPG for household needs	Gas demand for residential sector in Barrel of Oil Equivalent (BOE) REGt = i1 + i2* RPGASLt + i3*PDB + i4*REOLt + i5*REGt(-1) + U10 .... (3.15)	Ministry of Energy and Natural Resources (2013)
18	Consumption of Gas in Transport Sector (TRRTGt)	The use of light gas vehicle (LGV) and natural gas vehicle (NGV) in transport sector	Gas demand for transportation sector in Barrel of Oil Equivalent (BOE) TRRTGt = j1 + j2*RPOILPT + j3*RPGASIt + j4*PDBt + j5*TRRTGt(-1) + U11 .... (3.16)	Ministry of Energy and Natural Resources (2013)
19	Consumption of Gas in Commercial Sector (COMGt)	The use of natural gas and LPG for commercial and public sector	Gas demand for commercial sector in Barrel of Oil Equivalent (BOE) COMGt= k1 + k2*RPOILMTt + k3*RPGASLt + k4*COMEGt+ k5*COMPt+ k6*COMOLt + k7*COMGt(-1) + U12 .... (3.17)	Ministry of Energy and Natural Resources (2013)
20	Consumption of Coal in Electricity Generation Sector (EGCLt)	The use of coal to generate electricity at electricity generation sector	Coal demand in electricity generation sector in Barrel of Oil Equivalent (BOE) EGCLt = l1 + l2*RPOILDt + l3*RPCOALt + l4*JRT + l5*EGPt + l6*EGCLt(-1) + U13 .... (3.19)	Ministry of Energy and Natural Resources (2013)
21	Consumption of Coal in Industrial Sector (IDCLt)	The use of coal for industrial sector	Coal demand for industrial sector in Barrel Oil Equivalent (BOE) IDCLt = m1 + m2*RPOILSt + m3*RPCOALt + m4*INDPt + m5*IDCLt(-1) + U14 .... (3.20)	Ministry of Energy and Natural Resources (2013)

No	Name of Variable	Definition	Measurement	Data Source
22	Consumption of Coal in Residential Sector (RECLt)	The use of bricket as thermal energy for cooking in residential sector	Coal demand in residential sector in Barrel of Oil Equivalent (BOE) RECLt = n1 + n2* RPCOALt + n3*POPt + n4*RECLt(-1) + U15 .... (3.21)	Ministry of Energy and Natural Resources (2013)
23	Consumption of Electricity in Industrial Sector (IDEGt)	The use of electricity for industrial sector	Electricity demand for industrial sector in Barrel of Oil Equivalent (BOE) IDEGt = o1 + o2*RPOILSt + o3*RPGASIt + o4*RPELIt + o5*PDBt + o6*IDEGt(-1) + U16 .... (3.23)	Ministry of Energy and Natural Resources (2013)
24	Consumption of Electricity in Residential Sector (REEGt)	The use of electricity for household appliance	Electricity demand for residential sector in Barrel of Oil Equivalent (BOE) REEGt = p1 + p2* RPELRt + p3*POPt + p4*PDBt + p5*REEGt(-1) + U17 .... (3.24)	Ministry of Energy and Natural Resources (2013)
25	Consumption of Electricity in Commercial Sector (COMEGt)	The use of electricity for commercial sector	Electricity demand for commercial sector in Barrel of Oil Equivalent (BOE) COMEGt = q1 + q2*RPELKt + q3*COMPt + q4*COMEGt(-1) + U18 .... (3.25)	Ministry of Energy and Natural Resources (2013)
26	Petroleum Refinery Transformati on (OTPPt) ***(Identity)***	Crude oil and condesate refinery to produce oil fuel (gasoline, kerosene, aviation fuel, diesel, pertamax, etc) and non oil fuel product (LPG, lube base oil, petrochemical, naptha, asphalt, low sulfur waxy residue)	Petroleum refinery transformation is determined by the increase of crude oil input or refinery capacity and refinery efficiency or utilization in Barrel of Oil Equivalent (BOE) OTPPt = RFCRt * (1-RFUTt) .... (3.31)	Ministry of Energy and Natural Resources (2013)
27	Crude Oil Input for	Refinery crude oil input will have a	Refinery crude oil input is calculated as the product of	Ministry of Energy and

No	Name of Variable	Definition	Measurement	Data Source
	Refinery (RFCRt) ***(Identity)***	distillation process that changes its structure and composition in order to obtain useful products. Refinery input will be adapted to the type of crude oil and refinery specification.	refinery utilization and capacities in Barrel of Oil Equivalent (BOE). RFCRt = RCCRt * RFCICRt .... (3.30)	Natural Resources (2013)
28	Oil Fuel Production (YBBMt) ***(Identity)***	Production capabilities resulting from energy transformation process in oil refineries into oil fuel products, such as gasoline, kerosene, aviation fuel, diesel, pertamax, etc.	Oil fuel production is calculated as petroleum transformation output and refinery product ratio (oil fuel and non oil fuel), in Barrel of Oil Equivalent (BOE) YBBMt = OTPPt * OTPPRt .... (3.32)	Ministry of Energy and Natural Resources (2013)
29	Non Oil Fuel Production (YNBBMt) ***(Identity)***	Product resulted from the transformation process in oil refineries into non oil fuel products, such as LPG, lube base oil, petrochemical, naptha, asphalt, low sulfur waxy residue	Non oil fuel production is calculated as the difference between refinery transformation output and oil fuel production, in Barrel of Oil Equivalent (BOE). YNBBMt = OTPPt – YBBMt .... (3.33)	Ministry of Energy and Natural Resources (2013)
30	Crude Oil Supply (SCRt) ***(Identity)***	Available crude oil for domestic refineries demand which is obtained from net domestic production (excluding its export, import, and stock). Crude oil export consists of government production share that does not comply with refinery specification and contractor	The supply of crude oil is limited to domestic refinery capacities, in Barrel of Oil Equivalent (BOE). Import of crude oil (IMCRt) is calculated as the balance between refinery demand and supply. SCRt = RFCRt = IPOLt + IMCRt – EXOLt – CRBLNCt .... (3.34)	Ministry of Energy and Natural Resources (2013)

No	Name of Variable	Definition	Measurement	Data Source
		production share		
31	Oil Fuel Supply (SBBMt) ***(Identity)***	Availability of oil fuel for domestic needs, which is obtained from the difference between domestic petroleum refinery process with export, import, and stock	The supply of oil fuel for domestic needs is obtained from production and import, in Barrel of Oil Equivalent (BOE). Import of crude oil (IMPPt) is calculated as the balance between oil fuel demand and supply. SBBMt = FCOLt = YBBMt + IMPPt– PPBLNCt .... (3.35)	Ministry of Energy and Natural Resources (2013)
32	Oil Import (IMOLt) ***(Identity)***	Oil imports by importing crude oil and petroleum products (oil fuel and non oil fuel)	Total import of crude oil and petroleum products (oil fuel and non oil fuel) in Barrel of Oil Equivalent (BOE) IMOLt = IMCRt + IMPPt .... (3.36)	Ministry of Energy and Natural Resources (2013)
33	Total GDP (PDBt) ***(Identity)***	Total of Gross Domestic Bruto (GDP) per economic sector, including electricity generation, industrial, transport, commercial and other sector	Total GDP in trillion rupiah PDBt = EGPt + INDPt +TRPt + COMPt + OCPt .... (3.42)	Central of Statistical Bureau and Central Bank
34	GDP in Electrical Generation Sector (EGPt)	GDP obtained from electrical generation sector	GDP of electrical generation sector in trillion rupiah EGPt = w1 + w2*SKBRt + w3*POPt + w4*EGPt(-1) + U24 .... (3.37)	Central of Statistical Bureau and Central Bank
35	GDP of Industrial Sector (INDPt)	GDP obtained from processing industry sector	GDP of processing industry sector in trilion rupiah INDPt = x1+ x2*POILWDt + x3*SKBRt + x4*INDPt(-1) + U24 .... (3.38)	Central of Statistical Bureau and Central Bank

No	Name of Variable	Definition	Measurement	Data Source
36	GDP of Transport Sector (TRPt)	GDP obtained from transport sector, such as railway transportation, road, water, air, and transportation support	GDP of transport sector in trillion rupiah TRPt = y1 + y2* POILWDt + y3*SKBRt + y4*PDBt + y5*TRPt(-1) + U25 .... (3.39)	Central of Statistical Bureau and Central Bank
37	GDP of Commercial Sector (COMPt)	GDP obtained from commercial sector, such as trading, hotel, restaurant, financial institution, office, school, hospital, real estate, and service	GDP of commercial sector in trillion rupiah COMPt = z1 + z2*POILWDt + z3*COMPt(-1) + U26 .... (3.40)	Central of Statistical Bureau and Central Bank
38	GDP of Other Sector (OCPt)	GDP obtained from other sector, such as agriculture; gas and water supply; mining and quarrying	GDP of other sector in trillion rupiah OCPt = aa1 + aa2*POILWDt + aa3*SKBRt + aa4*EXCHt + aa5*OCPt(-1) + U27 .... (3.41)	Central of Statistical Bureau and Central Bank
39	Total Energy Consumption in Electricity Generation Sector (EGECt) ***(Identity)***	The use of the energy by the electricity generation sector, such as coal, natural gas, fuel, geothermal, and hydropower	The sum of energy consumption per type of energy at electricity generation sector in Barrel of Oil Equivalent (BOE) EGECt = EGGt + EGCLt + EGOLt + EGGTt + EGHYt .... (3.44)	Ministry of Energy and Natural Resources (2013)
40	Total Energy Consumption in Industrial Sector (IDECt) ***(Identity)***	Total energy demand (coal, natural gas, LPG, oil, and electricity) in industrial sector as combustion and feedstock. Fuels for transport in industrial sector are excluded.	The sum of energy consumption per type of energy at industrial sector in Barrel of Oil Equivalent (BOE) IDECt = IDGt + IDCLt + IDOLt + IDEGt .... (3.45)	Ministry of Energy and Natural Resources (2013)
41	Total Energy Consumption in	Total energy demand in residential sector, including natural gas,	The sum of energy consumption per type of energy at residential sector	Ministry of Energy and Natural

No	Name of Variable	Definition	Measurement	Data Source
	Residential Sector (REECt) ***(Identity)***	LPG, oil fuel, and electricity. Residential oil fuel demand for personal car is excluded from this calculation.	in Barrel of Oil Equivalent (BOE). REECt = REGt + RECLt + REOLt + REEGt ..... (3.46)	Resources (2013)
42	Total Energy Consumption in Commercial Sector (COMECt) ***(Identity)***	Total energy demand in commercial sector, including natural gas, LPG, oil fuel, and electricity.	The sum of energy consumption per type of energy at commercial sector in Barrel of Oil Equivalent (BOE). COMECt = COMEGt + COMOLt + COMEGt .... (3.47)	Ministry of Energy and Natural Resources (2013)
43	Total Energy Consumption in Transport Sector (TRECt) ***(Identity)***	Total energy demand (oil and gas fuel) in transport sector from all economic sectors, includes air, river, and sea transport. Small amount of electricity use at electric train is excluded from this calculation.	The sum of energy consumption per type of energy at transportation sector in Barrel of Oil Equivalent (BOE). TRECt = TREGt + TROLt .... (3.48)	Ministry of Energy and Natural Resources (2013)
44	Number of Vehicle (VEHIt)	Number of land vehicle, including light and heavy vehicle	The sum of land vehicle (unit) VEHIt = ab1 + ab2*TRPt + ab3*VEHI(-1) + U27 .... (3.49)	Central of Statistical Bureau
45	OTPPRT **(*Identity*)**	Petroleum product ratio between fuel and non fuel	OTPPRT = YBBMT/YNBBMT .... (3.53)	-
46	Gas Export (EXGT) ***(Identity)***	Natural gas, LPG, and LNG sales to other countries	Gas export is calculated as differences between production and domestic demand in Barrel of Oil Equivalent (BOE) EXGT = IPGT – ECGT .... (3.50)	Ministry of Energy and Natural Resources (2013)
47	Coal Export (EXCLT)	Coal sales to other countries	Coal export is calculated as differences between	Ministry of Energy and

No	Name of Variable	Definition	Measurement	Data Source
	(Identity)		production and domestic demand in Barrel of Oil Equivalent (BOE) EXCLT = IPCLT – FCCLT .... (3.51)	Natural Resources (2013)
48	Crude Oil Export (EXOLT) ***(Identity)***	Crude oil and condensate sales to other countries	Calculation of crude oil and condensate export comes from domestic oil production (government and contractor's share) that did not comply with domestic refinery specification and contractor's production split share in Barrel of Oil Equivalent (BOE) EXOLT = IPOLT*RPEXOLT .. (3.52)	Ministry of Energy and Natural Resources (2013)

CHAPTER IV

RESULT AND ANALYSIS

4.1. Result of Data Processing

The research model was made in four blocks, namely consumption, transformation, supply, and economic output. A total of 80 variables were included in 48 equations, consisting of 26 structural equations and 22 identity equations. The structural equation comprised 26 endogenous variables (G) and 28 predetermined variables (M), with total variables in the model (K) of 54 variables. Based on the explanation of order condition criteria in section 3.4.1, the energy balance model on this research is overidentified (K-M > G-1) and will be estimated by Two Stages Least Square (2SLS) method.

The following estimation result on four blocks of energy model will be used to answer research hypotheses.

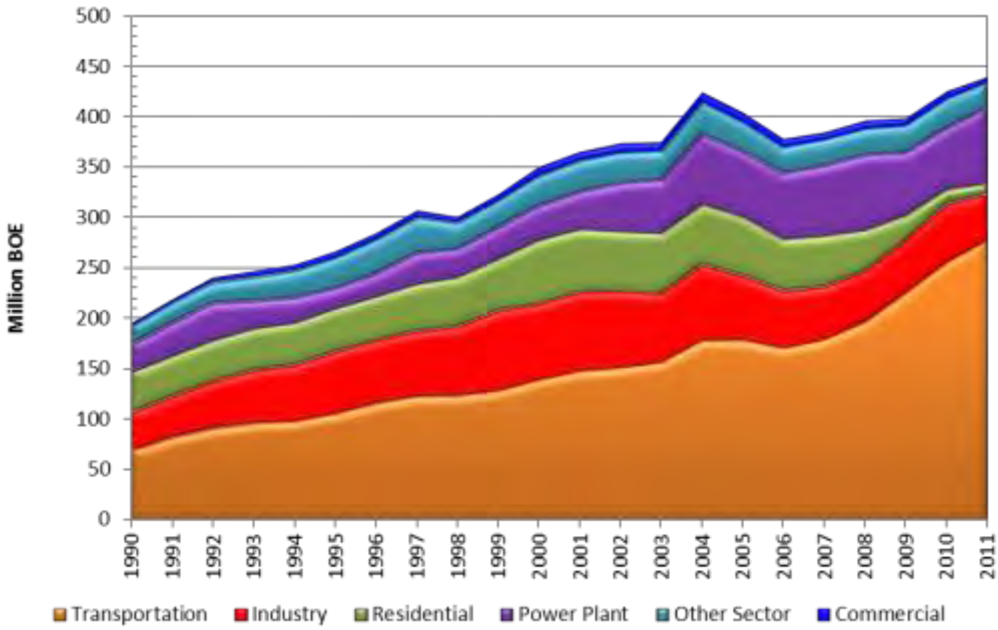
4.1.1. Energy Consumption Block

Nowadays, final energy mix in Indonesia includes seven main resources, which are oil, natural gas, coal, electricity, biomass, geothermal, and hydropower. The response of energy consumption may be estimated by applying 2SLS method to various forms of energy consumption at disaggregated sector energy users. Using t-test and R-square resulted from multiple regressions of 2SLS method in Appendix C Table C-2, significant factors determining overall energy consumption per disaggregated energy user from 1990 to 2011 will be analyzed. Steps of correlation test between variables are shown on Appendix D.

4.1.1.1 Oil Fuel Consumption

The sectoral oil fuel consumption in the last 21 years is presented in Chart 4.1. The table shows that the largest sectoral oil fuel consumption to date is transport sector followed by industrial, electricity generation, other sector, residential, and commercial respectively. Oil fuel consumption increased in average of 4 percent per year from 1990 to 2011. Declining consumption occured in 1998, 2005, and 2006 as the effect of world oil price shock which increased domestic gasoline price.

Chart 4.1 Sectoral Oil Fuel Consumption of the period from 1990 to 2011



Source: processed data

In 2011, the share of transport sector was accounted for 63 percent and has grown in average of 7 percent annually in the last 21 years. Before the year 2007, oil fuel consumption in this sector grew only at 6 percent per year and increased in average of 13 percent per year due to rapid economy's growth in Indonesia.

Table 4.1 Factors Affecting Oil Fuel Consumption at Disaggregated Sector Energy User

No.	Endogenous	Exogenous	Coefficient	Std. Error	t-Statistic	Prob.	R^2	Dw
a	COMOLT	C	2394.3280	738.1121	3.2439	0.0013 *	0.8626	2.0672
		RPOILMTT	-0.0037	0.0013	-2.8197	0.0050 *		
		SKBRT	-57.9711	27.2404	-2.1281	0.0339 *		
		COMOLT(-1)	0.8703	0.0914	9.5174	0.0000 *		
b	EGOLT	C	-42848.9000	18431.0200	-2.3248	0.0206 *	0.9379	1.8996
		RPOILDT	0.0552	0.0111	4.9645	0.0000 *		
		JRT	1.8214	0.4455	4.0887	0.0001 *		
		EGGT	-0.5692	0.1329	-4.2839	0.0000 *		
c	IDOLT	C	-89514.9200	25199.6800	-3.5522	0.0004 *	0.9261	2.1380
		RPOILDT	-0.0420	0.0122	-3.4329	0.0007 *		
		IDOLT(-1)	0.2457	0.1430	1.7183	0.0864 **		
		OGR_IN	74993.5000	27995.3800	2.6788	0.0077 *		
		JRT	2.1662	0.4845	4.4710	0.0000 *		
d	OCOLT	C	12760.3000	2949.4660	4.3263	0.0000 *	0.7530	1.7600
		RPOILST	-0.0062	0.0019	-3.2169	0.0014 *		
		OCOLT(-1)	0.7529	0.1100	6.8471	0.0000 *		
		SKBRT	-303.6808	81.1652	-3.7415	0.0002 *		
f	TROLT	C	11724.7600	13454.3700	0.8714	0.3840	0.9952	1.3225
		RPOILPT	-0.0894	0.0132	-6.7757	0.0000 *		
		RPGASIT	0.1555	0.0368	4.2214	0.0000 *		
		VEHI	1.7559	0.2475	7.0951	0.0000 *		
		PDB/POPT	6505.4740	2637.0890	2.4669	0.0140 *		
		TROLT(-1)	0.3095	0.1138	2.7209	0.0068 *		

*) Significant at $\alpha = 5\%$

**) Significant at $\alpha = 10\%$

Source: processed data

Table 4.1 summarizes the 2SLS estimation result of the disaggregated sector energy user on oil fuel consumption. It can be seen that oil fuel consumption is determined by the price of oil fuel (*RPOILMTt, RPOILPt, RPOILDt, RPOILSt*), price of gas (*RPGASIt*), number of residence (*JRt*), sectoral GDP, GDP per capita (*PDBt/POPt*), number of vehicle (*VEHI*), energy diversification ratio (*OGR*), gas consumption (*EGGt, REGt, TRRTGt*), interest rate (*SKBRt*), and oil fuel consumption in the previous period.

The total of oil fuel consumption (*FCOLt*) is calculated in an identity equation as the sum of the disaggregated sector energy users consuming oil fuel, i.e. commercial (*COMOLt*)*,* industrial (*IDOLt*)*,* electricity generation (*EGOLt*)*,* residential (*REOLT*)*,* transport (*TROLt*), and other sector (*OCOLt*).

a. Consumption of Oil Fuel in Commercial Sector (*COMOLt*)

Kerosene is one type of oil fuel that is widely used in commercial sector as thermal energy at restaurant, hotel, and catering services. But since 2005, the consumption of kerosene at this sector has been decreasing by 5 percent per year due to government's conversion program from kerosene to LPG.

Table 4.1 point a shows that oil fuel consumption at commercial sector (*COMOLt*) is affected by price of kerosene (*RPOILMTt*), interest rate (*SKBRt*), and lagged oil fuel consumption (*COMOLt(-1)*) with the following explanation.

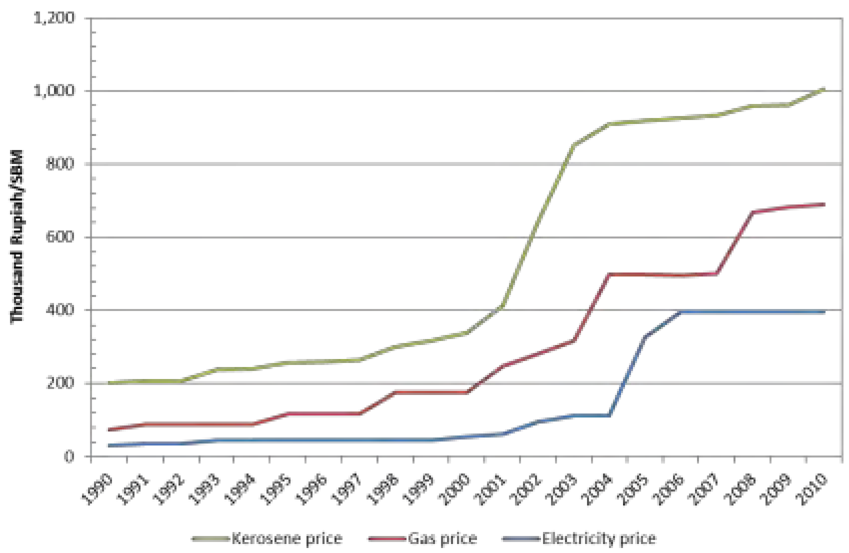
Price of kerosene and interest rate has significant correlation and negative relationship with oil fuel consumption in commercial sector. The lower the price of kerosene, the more kerosene will be consumed. This fits Theory of Demand, wherein consumption depends on the price of goods. Moreover, the lower interest rate will give a positive impact on the investment climate in commercial sector to encourage the increase of energy demand in terms of oil fuel as one input in production factor.

The lagged oil fuel consumption in commercial sector has a positive relationship and significant correlation, showing that the current consumption of oil fuel is affected by the previous behavior.

The result of R-square test on *COMOLt* is 86.3 percent, indicating that all exogenous variables in the model can jointly explain the consumption of oil fuel in commercial sector, while the rest is explained by other factors.

Prices of other energy, such as gas and electricity, are dropped from the equation because they have no significant correlation with the consumption of oil fuel (sig > 0.05 and sig > 0.1). The result is obtained because during the research period, the price of gas and electricity were cheaper than the price of oil fuel, as shown in Chart 4.2.

Chart 4.2 Price of Kerosene, Gas and Electricity of the period from 1990 to 2011



Source: processed data

b. Consumption of Oil Fuel in Electricity Generation Sector (*EGOLt*)

Oil fuel consumption in electricity generation sector grew in average of 7 percent per year from 1990 to 2008 and slightly decreased after 2009 due to government's conversion program from oil fuel to other energy sources (coal, gas, and renewable energy) in order to reduce cost of energy subsidy.

Table 4.1 point b shows that the consumption of oil fuel in electricity generation sector (*EGOLt*) is affected by the price of oil fuel (*RPOILDt*), number of residence (*JRT*), and consumption of gas (*EGGt*) as energy substitution, with the following explanation.

The number of residential and price of oil fuel has significant correlation and positive relationship with oil fuel consumption in electricity generation sector. More residence needs more electricity (Alberini and Filippini, 2010; Salman *et al.*, 2008), thus the demand of energy source (oil fuel) for electricity generation will increase.

The relationship between price and oil fuel consumption indicates positive relationship that does not fit Theory of Demand. A possible explanation of this evidence is because there are government distortions in oil fuel price subsidies for PT. PLN to generate electricity that will not influence the consumption of oil fuel.

Several power plants are operated in dual fuel (oil and gas) engine that makes the consumption of gas has a significant correlation and negative relationship with the consumption of oil fuel in electricity generation sector. This condition is in accordance with the concept of substitution effect, in which the increasing use of gas to generate electricity will replace and reduce demand of oil fuel.

The result of R-square test on *EGOLt* is 93.8 percent, indicating that all exogenous variables in the model can jointly explain the consumption of oil fuel in electricity generation sector and the rest is explained by other factors.

Prices of other energy, such as gas and coal, are dropped from the equation because they have no significant correlation with oil fuel consumption (sig > 0.05 and sig > 0.1). There are two reasons to explain the result. First, the operations of electricity generators are adapted to the type of energy source and are not substitutive. Second, the policy of oil fuel subsidy makes the relative price of other energy being not competitive.

c. Consumption of Oil Fuel in Industrial Sector (*IDOLt*)

The consumption of oil fuel in industial sector grew in average of 7 percent per year from 1990 to 2001 and started to decrease at 3 percent per year from 2002 to 2010 due to fuel substitution program to coal and gas. Likewise to residential sector, oil fuel consumption in this sector has been decreasing since 2007 by 22 percent per year due to conversion program from kerosene to LPG.

Table 4.1 point c shows that oil fuel consumption in industrial sector (*IDOLt*) is affected by the price of oil fuel (*RPOILDt*), number of residence (*JRT*), energy diversification or ratio between oil and gas consumption (*OGR_IN*), and lagged oil fuel consumption (*IDOLt(-1)*), as explanated below.

Price of oil fuel has significant correlation and negative relationship with the consumption of oil fuel in industrial sector. The lower the price of oil fuel, the more oil fuel will be consumed. This condition fits Theory of Demand, in which the demand of goods or services depends on its price.

In contrast, the number of residence, energy diversification, and lagged oil fuel consumption has significant correlation and positive relationship with the consumption of oil fuel in industrial sector. The higher the number of residence, the more the industrial output requested. It will increase the production of goods which requires energy as an input of production factor.

The variable of oil and gas consumption ratio is used in this model as a proxy of diversification program implementation from oil to gas since 2002 with a purpose to address the effect of the increasing domestic oil price to production costs that will reduce the production output. In this view, higher oil price will reduce oil demand and shift oil usage to other energy.

The lagged oil fuel consumption has positive relationship, showing that the current oil fuel consumption is affected by the previous behavior. The experts' suggestion to insert dynamic function in order to determine previous demand behavior (lagged variable) can be used in this equation.

The result of R-square test on the *IDOLt* is 92.6 percent, indicating that all exogenous variables in the model can jointly explain the consumption of oil fuel in industrial sector and the rest is explained by other factors.

The prices of other energy (gas, electricity, and coal) and GDP of industrial sector are dropped from the equation because they have no significant correlation with oil fuel consumption (sig > 0.05 and sig > 0.1). There are two reasons to explain the result. First, the equipment used in industrial sector requires energy that cannot be easily replaced, making the changes of other energy price not sensitive to the consumption. Second, the evidence from the next section suggests that GDP will be statistically significant on the dominant type of energy used in disaggregated sectors. The disagregated data of energy consumption in industrial sector shows that coal is a dominant type of energy used in a share of 42 percent, followed by natural gas (35 percent), oil fuel (13 percent), and electricity (10 percent).

d. Consumption of Oil Fuel in Other Sector (*OCOLt*)

Table 4.1 point d shows that oil fuel consumption in other sector (*OCOLt*) is affected by the price of oil fuel (*RPOILSt*), interest rate (*SKBRt*), and lagged oil fuel consumption (*OCOLt(-1)*), with the following explanation.

The price of oil fuel and interest rate has a negative relationship and significant correlation with the consumption of oil fuel in other sector. The lower the price of oil fuel, the more oil fuel will be consumed. This condition fits the Demand Theory, wherein the demand of goods or services depends on its price. The lower interest rate will give positive impact on the investment climate in other sector and encourage the increase of energy consumption as one input of production factor.

The lagged oil fuel consumption has a positive relationship and significant correlation, showing that the current consumption of oil fuel is affected by the previous behavior.

The result of R-square test on *IDOLt* is 75.3 percent, indicating all exogenous variables in the model can jointly explain the consumption of oil fuel in other sector and the rest is explained by other factors.

e. Consumption of Oil Fuel in Residential Sector (*REOLt*)

Table 4.1 point e shows that the consumption of oil fuel at residential sector (*REOLt*) is affected by the price of gas (*RPGASLt*), number of residence (*JRT*), income per capita (*PDB/POPt*), and energy diversification or ratio between kerosene and total oil and gas consumption (*OGR*), as the following explanation.

Until 2005, kerosene is one of energy that is widely used at residential sector as thermal energy for cooking purpose after firewood. Policy of conversion program, i.e. substituting the use of kerosene to LPG in 2005 by providing free LPG, stove, and subsidizing LPG price for residences decreased kerosene consumption and increased LPG consumption by almost 80 percent. This policy is reasonable in order to make energy diversification and price of gas variables has positive and negative relationship respectively, with significant correlation to the consumption of oil fuel in residential sector.

Number of residence has positive relationship and significant correlation with the consumption of oil fuel in residential sector, while the income per capita has negative relationship. The larger the number of residential, the more oil fuel will be consumed. The increase of income and purchasing power makes consumers switch to a cleaner and readily available energy, like gas and electricity, which will reduce oil fuel consumption (Stern, 2000; Matheny, 2010).

The empirical result shows that the price of oil fuel is statistically significant to its consumption at a significance level of 35 percent, thus dropping this variable from the equation. There are two reasons to explain the result, i.e. the cost reduction of oil fuel subsidy and the conversion policy. Reduction in energy subsidy cost will lead to the increasing domestic oil fuel price, followed by the conversion program which reduces oil fuel (kerosene) consumption in residential sector significantly.

The result of R-square test on *REOLt* is 97.98 percent, indicating that all exogenous variables in the model can jointly explain the consumption of oil fuel in other sector and the rest is explained by other factors.

f. Consumption of Oil Fuel in Transportation Sector (*TROLt*)

Table 4.1 point f shows that oil fuel consumption at transportation sector (*TROLt*) is affected by the price of gasoline (*RPOILPt*), price of gas (*RPGASIt*), number of vehicle (*VEHI*), income per capita (*PDB/POPt*), and lagged oil fuel consumption (*TROLt(-1)*) as the following explanation.

Except for the lagged oil fuel consumption, all estimation has the expected positive sign that is statistically significant to the consumption of oil fuel in transportation sector.

The increasing economic activities and purchasing power without the support of adequate and convenient mass transportation facilities leads to the increasing demand for private cars to meet the needs of mobility that will lead to the increase of oil fuel consumption.

Based on Central of Statistical Bureau's data in 2011, the number of motorcycle grew by 16 percent per year during 2007 until 2011 while private car grew by 9 percent per year, totaling the vehicle to 86 milion. The lagged oil fuel consumption which has positive relationship and significant correlation indicates that the current consumption is affected by past behavior.

In contrast, price of gasoline has negative relationship with the consumption of oil fuel. The lower the price of gasoline, the more oil fuel will be consumed. This fits Theory of Demand wherein the demand of goods or services depends on its price. The historical data shows that the reduction of gasoline price in 2009 led to the increase of oil fuel consumption by 13 percent from the previous year's consumption.

The result of R-square test on the *TROLt* is 99.5 percent, indicating that all exogenous variables in the model can jointly explain the consumption of oil fuel in other sector and the rest is explained by other factors.

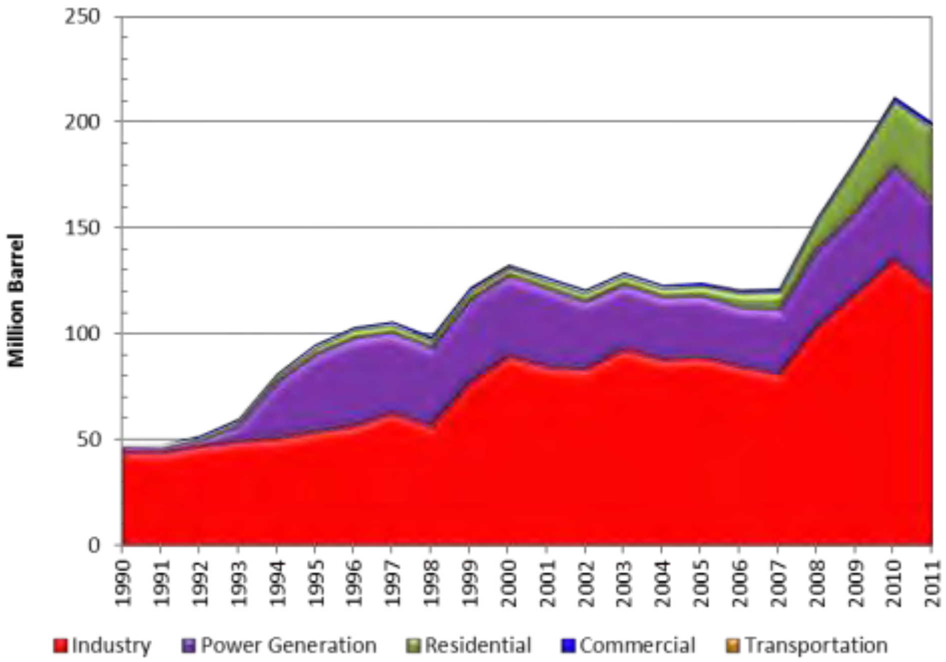
4.1.1.2 Gas Consumption

Consumption of natural gas per sectoral energy user in the last 21 years is shown in Chart 4.3. The demand of natural gas has been significantly increasing. In 2011, Indonesia only consumed 37 percent of natural gas compare to its production, mainly for industries and electricity, while 60 percent of its production was processed into Liquefied Natural Gas (LNG) to meet the needs of ASEAN market like Japan, South Korea, and Taiwan (50 percent) and exported to Singapore and Malaysia through pipeline (10 percent).

Chart 4.3 presents sectoral consumption of natural gas and LPG. This disaggregated data shows that gas utilization in the form of city gas at residential and commercial sector is slightly increasing due to the limited gas pipeline infrastructure. LPG has been used in both sectors since 2007 as a result of conversion program from kerosene to LPG.

From 1990 until 2011, gas consumption increased in average of 8 percent per year. The larger increase occurred in the period of 1993-1997 and 2007-2010 as the impact of conversion program and subsidy cuts that forced all economic sectors shifting to non-oil energy source.

Chart 4.3 Consumption of Gas per Sectoral Energy User period 1990-2011



Source: processed data

Table 4.2 summarizes the 2SLS estimation result of the disaggregated sector energy users on gas consumption. It shows that gas consumption will be determined by the price of gas fuel (*RPGASIt, RPGASLt*), sectoral GDP, GDP per capita (*PDBt/POPt*), energy diversification ratio (*OGR_IN, OGR_COM, OGR_EG, OGR_TR*), consumption of oil fuel, and lagged gas consumption.

Total gas consumption (*ECGt*) is calculated as an identity equation from the sum of disaggregated sector energy users consuming gas, such as commercial (*COMGt*), industrial (*IDGt*), electricity generation (*EGGt*), residential (*REGt*), and transportation (*TRRTGt*) sector.

Table 4.2 Factors Affecting Gas Consumption of Disaggregated Sector Energy Users

No.	Endogenous	Exogenous	Coefficient	Std. Error	t-Statistic	Prob.	R^2
a	COMGT	C	-94.3704	299.0002	-0.3156	0.7524	0.7775
		RPELIT	-0.0007	0.0004	-1.9830	0.0480 *	
		COMPT	0.0015	0.0005	3.0190	0.0027 *	
		COMGT(-1)	0.5362	0.2076	2.5830	0.0101 *	
		1-(OGR_COM)	2588.2640	1323.4270	1.9557	0.0512 *	
b	EGGT	C	-10519.1300	1974.7180	-5.3269	0.0000 *	0.9851
		RPGASIT	0.0301	0.0137	2.1879	0.0292 *	
		PDBT	0.0081	0.0017	4.8221	0.0000 *	
		EGGT(-1)	0.1966	0.0702	2.7999	0.0053 *	
		1-OGR_EG	48138.9500	4229.0070	11.3830	0.0000 *	
c	IDGT	C	-100793.2000	21309.5500	-4.7300	0.0000 *	0.9649
		RPOILST	-0.0593	0.0135	-4.4008	0.0000 *	
		RPGASIT	0.1876	0.0353	5.3128	0.0000 *	
		INDPT	0.1115	0.0353	3.1624	0.0017 *	
		1-OGR_IN	228036.1000	43127.9100	5.2874	0.0000 *	
d	REGT	C	-7805.6680	2196.8810	-3.5531	0.0024 *	0.9918
		JRT	0.4712	0.0684	6.8890	0.0000 *	
		REGT(-1)	0.6303	0.0871	7.2330	0.0000 *	
		REOLT	-0.2776	0.0365	-7.6116	0.0000 *	
e	TRRTGT	C	-16.6229	23.8782	-0.6962	0.4867	0.6038
		RPGASIT	0.0006	0.0001	4.7846	0.0000 *	
		1-OGR_TR	71545.5700	26423.9100	2.7076	0.0070 *	

*) Significant at $\alpha = 5\%$
**) Significant at $\alpha = 10\%$
Source: processed data

a. Consumption of Gas in Commercial Sector (*COMGt*)

Table 4.2 point a shows that the consumption of gas in commercial sector (*COMGt*) is affected by the price of electricity (*RPELIt*), GDP of commercial sector (*COMPt*), energy diversification or ratio of gas consumption to oil and gas (*1-OGR_COM*), and lagged gas consumption (*COMGt(-1)*), as the following explanation.

GDP of commercial sector, energy diverisification, and lagged gas consumption has positive relationship and significant correlation with the consumption of gas in commercial sector. The increasing GDP in commercial sector will provide the opportunities of business expansion which requires more energy. Variable of gas consumption to oil and gas consumption ratio are used as an implementation of energy diversification program from oil to gas that has been occurred since 2005. The higher the gas user ratio, the more gas will be consumed.

In contrast, the price of electricity and gas consumption has negative relationship and significant correlation, indicating that higher price of other energy will reduce gas consumption. This condition does not fit Theory of Demand, wherein the empirical result shows that the increase of other energy price will increase the consumption of gas.

The result of R-square test on *COMGt* is 77.7 percent, indicating that all exogenous variables in the model can jointly explain the consumption of gas in commercial sector and the rest is explained by other factors.

The implementation of energy conversion from oil to LPG in commercial sector in 2005 led to no significant correlation between price of oil and gas to the gas consumption, dropping the variables from the equation (sig > 0.05 and sig > 0.1).

b. Consumption of Gas in Electricity Generation Sector (*EGGt*)

Table 4.2 point b shows that the consumption of gas in electricity generation sector (*EGGt*) is affected by the price of gas (*RPGASIt*), GDP (*PDBt*), energy diversification or ratio of gas to oil and gas consumption (*OGR_EG*) and, the previous gas consumption in electricity generation sector (*EGGt(-1)*), as explained below.

GDP, price of gas, energy diversification, and gas consumption of the previous period has positive relationship and significant correlation with gas consumption in commercial sector. More purchasing power will result in more energy consumption for household appliances (MoEMR, 2010b), thus increasing energy supply to generate electricity. In addition, the increasing GDP will be used to develop power plant capacity that will increase national electricity ratio.

Positive sign of gas price (*RPGASIt*) in the regression is not in accordance with the Theory of Consumption wherein the increase of price will reduce the consumption of gas because the price of gas during research period was cheaper than price of other energy, especially oil fuel. So, the rising gas price at any level below oil price will not reduce the consumption of gas.

The enhancement of energy diversification program will increase gas demand and reduce oil fuel consumption. In 2011, the ratio between gas and oil as an energy source in electricity generation was 44 percent, increasing from 33 percent in 2008. This ratio variable will be used in research simulation in the next subsection in order to estimate oil fuel reduction as a result of energy diversification program in electricity generation sector.

The empirical result shows that the price of oil fuel has no significant correlation with the consumption of gas due to oil fuel subsidy, dropping it from the equation. However, higher cost of subsidy in national budget prompt the government to issue an energy policy to reduce oil fuel consumption as an energy source to generate electricity. Presidential Regulation No.05/2006 on National Energy Policy was issued to reduce the share of oil fuel in national energy mix and to switch to utilize other energy source such as gas, coal, and other renewable energy.

The result of R-square test on *EGGt* is 98.5 percent, indicating that all exogenous variables in the model can jointly explain the gas consumption in electricity generation sector and the rest is explained by other factors.

c. Consumption of Gas in Industrial Sector (*IDGt*)

Table 4.2 point c shows that the consumption of gas in industrial sector (*IDGt*) is affected by the price of gas (*RPGASIt*), price of oil fuel (*RPOILSt*), GDP of industrial sector (*INDPt*), and the ratio of oil fuel consumption to oil and gas (*OGR_EG*), as the following explanation.

GDP of industrial sector, energy diversification, and price of gas has positive relationship and significant correlation with consumption in industrial sector. The increasing GDP in industrial sector will provide opportunities of business and capital expansion that will directly increases energy consumption. Enhancement of energy diversification program will increase gas demand and reduce consumption of oil fuel.

Positive sign of gas price (*RPGASIt*) in the regression is not in accordance with the Theory of Consumption, wherein the increase of price will reduce the consumption of gas because the price of gas during research period was cheaper than price of other energy, especially oil fuel. So the rising gas price at any level below oil price will not reduce the consumption of gas.

Price of oil fuel and gas consumption has negative relationship and significant correlation, indicating that higher price of other energy will reduce gas consumption. This condition does not fit Theory of Demand, wherein the empirical result shows that the increase of other energy price will increase the consumption of gas.

The result of R-square test on *EGGt* is 96.5 percent, indicating that all exogenous variables in the model can jointly explain the gas consumption in industrial sector and the rest is explained by other factors.

d. Consumption of Gas in Residential Sector (*REGt*)

Table 4.2 point d shows that consumption of gas in residential sector (*REGt*) is affected by the number of residence (*JRT*), consumption of oil fuel (*REOLt*), and the previous gas consumption in residential sector (*REGt(-1)*), as the following explanation.

Consumption of oil fuel has negative relationship and significant correlation with the consumption of gas. This fits the Theory of Substitution; the reduction of oil fuel consumption will induce consumption of gas as thermal energy for cooking purpose. Historical data shows that this condition has been occurred since 2005 as a result of conversion program from kerosene to LPG.

The number of residence and the previous gas consumption has positive relationship and significant correlation, indicating that the current gas demand depends on the number of residence and the past consumption behavior.

The result of R-square test on *EGGt* is 99.2 percent, indicating that all exogenous variables in the model can jointly explain the gas consumption in residential sector and the rest is explained by other factors.

The price of gas was dropped from the equation because it has no significant correlation with the consumption of gas in residential sector (sig > 0.1). This condition occurs due to natural gas or LPG is a mandatory energy to replace the use of kerosene for cooking purposes in conversion program, so the residences which have already been using LPG will not reuse the kerosene.

e. Consumption of Gas in Transportation Sector (*TRRTGt*)

Table 4.2 point e shows that the consumption of gas in transportation sector (*TRRTGt*) is affected by the price of CNG (*RPGASIt*) and the ratio of oil consumption to oil and gas consumption (*OGR_TR*), as the following explanation.

The price of CNG has positive relationship and significant correlation with the consumption of gas in transportation sector due to the price of CNG during research period was cheaper than the price of oil fuel, so the increasing CNG price at any level below oil fuel price will not reduce gas consumption.

The undeveloped CNG consumption in the transport sector is due to unavailability of infrastructure facilities, such as CNG fueling stations, gas pipelines from the gas source to the stations, and converter kits for vehicles. In the future, CNG consumption will increase as the implementation of government policy to diversify oil fuel to CNG. It is reflected in the ratio of oil fuel consumption to oil and gas demand in the transportation sector which has positive relationship and significant correlation, thus the increasing ratio of gas consumption in transportation sector will increase the consumption of CNG.

The result of R-square test on *EGGt* is 60.4 percent, indicating that all exogenous variables in the model can jointly explain gas consumption in transportation sector and the rest is explained by other factors.

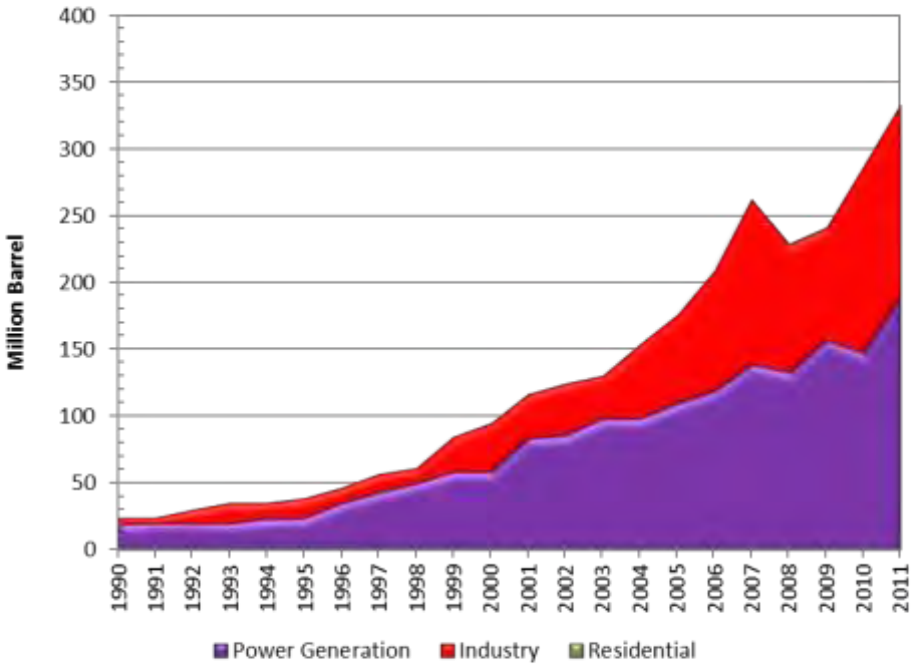
4.1.1.3 Coal Consumption

Being the cheapest and the most abundant fossil fuel, coal will always have a role in energy mix in Indonesia. Coal is slowly beginning to replace petroleum's role as a major energy source in power generation and industrial sectors. Increasing oil price makes the industries switch to use coal, which is cheaper. During period from 1998 to 2011, consumption of coal as the final energy increased rapidly from 62 million BOE to 334 million BOE, growing in an average of 14 percent per year.

In 2011, coal is mainly used for power generation and industry in a share of 51 percent and 48 percent respectively. Residential sector consumes coal in a very small amount.

Table 4.3 summarizes the 2SLS estimation result of the disaggregated sector energy users on coal consumption. It shows that coal consumption will be determined by the price of oil fuel (*RPOILDt, RPOILSt*), price of coal (*RPCOALt*), sectoral GDP, population (*POPt*), and the previous coal consumption.

Chart 4.4 Consumption of Coal per Sectoral Energy User of the period from 1990 to 2011



Source: processed data

Total consumption of coal (*EGCLt*) is calculated as an identity equation from total coal demand by sectoral energy user, such as industrial (*IDCLt*), electricity generation (*EGCLt*), and residential (*RECLt*) sectors.

Table 4.3 Factors Affectng Coal Consumption of Disaggregated Sector Energy Users

No.	Endogenous	Exogenous	Coefficient	Std. Error	t-Statistic	Prob.	R^2
a	EGCLT	C	-386404.7000	77087.8600	-5.0125	0.0000 *	0.9715
		RPOILDT	0.0520	0.0272	1.9078	0.0571 *	
		PDB	0.0096	0.0207	0.4606	0.0453 *	
		POPT	2.1029	0.4975	4.2268	0.0000 *	
b	IDCLT	C	-63220.5000	27039.4400	-2.3381	0.0198 *	0.9047
		RPOILST	0.0730	0.0284	2.5693	0.0105 *	
		INDPT	0.2113	0.0800	2.6416	0.0086 *	
c	RECLT	C	-117.0002	56.4945	-2.0710	0.0389 *	0.9891
		RPCOALT	-0.0001	0.0001	-2.4688	0.0139 *	
		POPT	0.0007	0.0003	2.1951	0.0287 *	
		RECLT(-1)	0.8080	0.0986	8.1919	0.0000 *	

*) Significant at $\alpha = 5\%$

**) Significant at $\alpha = 10\%$

Source: processed data

a. Consumption of Coal in Electricity Generation Sector (*EGCLt*)

Table 4.3 point a shows that the consumption of coal in electricity generation sector (*EGCLt*) is affected by the price of oil fuel (*RPOIDt*), population (*POPt*), and GDP (*PDBt*), as explained below.

The price of oil fuel, population, and GDP has positive relationship and significant correlation with coal consumption in electricity generation sector. The increasing price of diesel oil will make PT.PLN switch to using other kind of energy sources, such as coal and gas to generate electricity, thus increasing the consumption of coal. This fits the law of demand on substitution effect that is determined by the price change.

Coal is the major energy source for electricity generation sector. The bigger the number of population, the more electricity will be consumed and the more energy sources will be needed to generate electricity. The increasing national income will be used by this sector to generate more electricity through the investment of new power plant that will need more energy source, especially coal.

The result of R-square test on *EGCLt* is 97.1 percent, indicating that all exogenous variables in the model can jointly explain the coal consumption in electricity generation sector and the rest is explained by other factors.

The price of coal was dropped from the equation because it has no significant correlation with coal consumption (sig > 0.1). This occurs because the price of coal during research period was cheaper than the price of other energy, especially oil fuel. So the rising price of coal in any level below oil price will not reduce the consumption of coal. In addition, the change in primary energy price in electricity generation sector is not necessarily substitutable.

b. Consumption of Coal in Industrial Sector (*IDCLt*)

Table 4.3 point b shows that the consumption of coal in industrial sector (*IDCLt*) is affected by the price of diesel fuel (*RPOISt*) and GDP of industrial sector (*INDPt*), as the following explanation.

The price of oil fuel and GDP of industrial sector has positive relationship and significant correlation with the consumption of coal at industrial sector, indicating that the increasing diesel fuel price induces the industrial sector to switch to other energy source like coal which will increase the consumption of coal. This fits the law of demand on substitution effect that is determined by the price change.

The increasing sectoral GDP was used to increase the production output, thus requires more energy source. Coal began to be used as energy source in industrial sector to reduce dependence on oil fuel, especially in heavy and large industries like metallurgy, cement, and ceramics.

The result of R-square test on *IDCLt* is 90.5 percent, indicating that all exogenous variables in the model can jointly explain the coal consumption in industrial sector and the rest is explained by other factors.

Similar to the explanation in the previous point, price of coal was dropped from the equation because it has no significant correlation with coal consumption (sig > 0.1).

c. Consumption of Coal in Residential Sector (*RECLt*)

Table 4.3 point c shows that the consumption of coal in residential sector (*RECLt*) is affected by the price of coal (*RPCOALt*), population (*POPt*), and the coal consumption of the previous period (*RECLt(-1)*), as the following explanation.

The price of coal has negative relationship and significant correlation with the consumption of coal in residential sector. The lower the price of coal, the more coal will be consumed. The price of coal in the form of bricket is relatively cheaper than other energy, such as kerosene, but has not been widely used.

In contrast, populations and coal consumption in the previous period have positive relationship and significant correlation with coal consumption in residential sector. Coal is not popular for the people with high purchasing power, thus dropping the variable of income per capita from the model. Nevertheless, the population and coal consumption shows the proportional relationship. Consumption of coal in residential sector is also affected by the consumption in the previous period

The result of R-square test on *IDCLt* is 98.9 percent, indicating that all exogenous variables in the model can jointly explain the coal consumption in industrial sector and the rest is explained by other factors.

4.1.1.4 Electricity Consumption

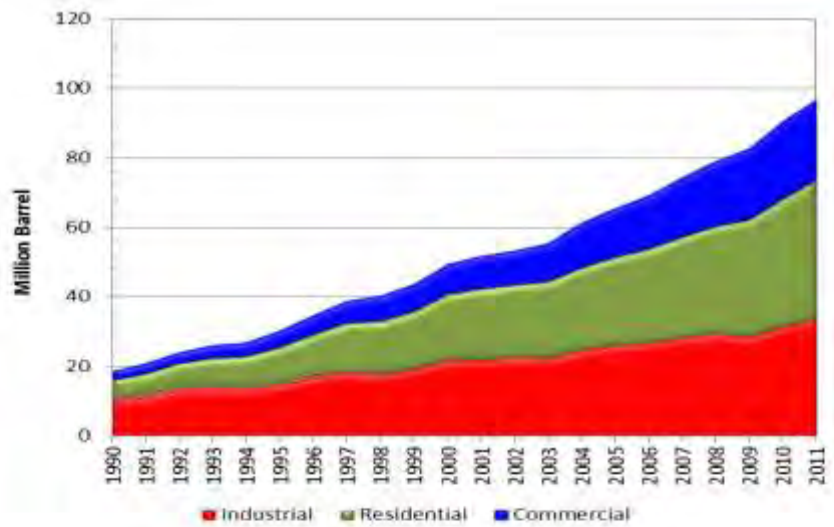
Sectoral consumption of electricity is shown on Chart 4.5. In the past 21 years, electricity consumption has been increasing by an average of 8 percent per year used by three major sectors, such as industrial, residential, and commercial sector. Consumption of electricity in transport sector for electric trains is very small and not significant.

In early 1990, the industrial sector dominated electricity use in a share of 56 percent. In 2011, electricity consumption in residential sector has surpassed industrial sector in a share of 41 percent with an average growth of 10 percent per year, while industrial sector only consumed in a share of 35 percent with an average growth of 6 percent per year.

Table 4.4 summarizes the 2SLS estimation result of the disaggregated sector energy users on electricity consumption. It shows that electricity consumption will be determined by the price of oil fuel (*RPOILMt*), price of electricity (*RPELRt*), sectoral GDP, GDP per capita (*POPt*), and the electricity consumption of the previous period.

Total consumption of electricity (*FCEGt*) is calculated as an identity equation from total electricity demand by sectoral energy user, such as industrial (*IDEGt*), commercial (*IDEGt*) and residential (*REEGt*) sector.

Chart 4.5 Consumption of Electricity per Sectoral Energy User of the period from 1990 to 2011



Source: processed data

Table 4.4 Factors Affecting Electricity Consumption of Disaggregated Sector Energy Users

No.	Endogenous	Exogenous	Coefficient	Std. Error	t-Statistic	Prob.	R^2
a	COMEGT	C	257.2370	150.7546	1.7063	0.0887 **	0.9975
		RPELIT	0.0011	0.0006	1.8383	0.0667 **	
		COMEGT(-1)	1.0033	0.0362	27.6958	0.0000 *	
b	IDEGT	C	1642.6460	1275.1550	1.2882	0.1984	0.9859
		RPGASIT	0.0275	0.0060	4.5620	0.0000 *	
		RPELIT	0.0031	0.0015	2.0515	0.0408 *	
		INDPT	0.0340	0.0047	7.3004	0.0000 *	
c	REEGT	C	-2250.6020	941.3899	-2.3907	0.0172 *	0.9987
		RPELRT	-0.0019	0.0007	-2.6699	0.0079 *	
		PDB/POPT	549.1790	188.8621	2.9078	0.0038 *	
		REEGT(-1)	1.0487	0.0384	27.3438	0.0000 *	

*) Significant at $\alpha = 5\%$

**) Significant at $\alpha = 10\%$

Source: processed data

a. Consumption of Electricity in Commercial Sector (*COMEGt*)

Table 4.4 point a shows that the consumption of electricity in commercial sector (*COMEGt*) is affected by the price of electricity (*RPELIt*) and the consumption of electricity at the previous period (*COMEGt(-1)*), as the following explanation.

The price of electricity and the consumption of electricity at the previous period have positive relationship and significant correlation with the consumption of electricity at commercial sector. This relation makes the increase of electricity price will increase the electricity consumption. It does not fit the Theory of Demand, wherein the increase of electricity price should reduce its consumption. This condition occurs because electricity is a necessity that cannot be substituted easily and quickly. The more economic growth in commercial sector, the more electricity will be consumed.

The result of R-square test on *COMECt* is 99.75 percent, indicating that all exogenous variables in the model can jointly explain the electricity consumption in commercial sector and the rest is explained by other factors.

b. Consumption of Electricity in Industrial Sector (*IDEGt*)

Table 4.4 point b shows that the consumption of electricity in industrial sector (*IDEGt*) is affected by the price of electricity (*RPELIt*), price of gas (*RPGASIt*), and GDP of industrial sector (*INDPt*), as explained below.

The price of electricity, price of gas, and GDP of industrial sector have positive relationship and significant correlation with the consumption of electricity. High income can be used by the sector to increase production through the use of capital investment for machinery and industrial technologies that directly require more energy source. Positive relationship between the price of electricity and the consumption is not in accordance with the Theory of Demand because it cannot be substituted easily and quickly in industrial sector.

The result of R-square test on *IDEGt* is 98.6 percent, indicating that all exogenous variables in the model can jointly explain the electricity consumption in industrial sector and the rest is explained by other factors.

c. Consumption of Electricity in Residential Sector (*REEGt*)

Table 4.4 point c shows that the consumption of electricity in residential sector (*REEGt*) is affected by the price of electricity (*RPELRt*), GDP per capita (*PDBt/POPt*), and the electricity consumption in the previous period (*REEGt(-1)*), as the following explanation.

The price of electricity has negative relationship and significant correlation with the electricity consumption. The increase of electricity price will reduce the consumption in residential sector. Currently, government subsidizes the price of electricity in different amount for each level of electricity user. Electricity subsidies are awarded to residences at the lowest level of electrical use (450 watt) as the largest user.

GDP per capita and electricity consumption in the previous period have positive relationship and significant correlation with electricity consumption in residential sector. Electricity consumption will increase in line with the growth of

GDP per capita. The higher the household's purchasing power, the more home appliances will be used and the more electricity will be consumed (Dilaver, 2012; Fell *et al.*, 2010; Hartman, 1979). But at a certain level, the residence's electricity demand will be relatively constant and is not influenced by the increasing purchasing power. The increase of purchasing power also has an effect on the type of energy used. Richer household will use a more modern and cleaner energy, such as electricity and gas.

The result of R-square test on the *REEGt* is 99.8 percent indicates that all exogenous variables in the model can jointly explain the electricity consumption in residential sector and the rest is explained by other factors.

4.1.1.5 Biomass Consumption

Biomass is a natural energy source, mostly comes from agricultural crops and residues, forest waste, commodities of plantation, and animal waste. Traditional biomass in the form of firewood is mostly used by household at rural areas to provide energy for cooking, heat, and electricity (Dwiprabowo, 2010). In the last 20 years, biomass consumption has a steady growth of 2 percent per year, as shown in Chart 4.6. Uneven economic development and low electrification ratio have induced the use of traditional biomass as the main energy in rural household due to its cheap price and availability.

The estimation result of biomass consumption in residential sector (*REBIOt*) in Table 4.5 shows that the consumption of biomass depends on price of oil fuel

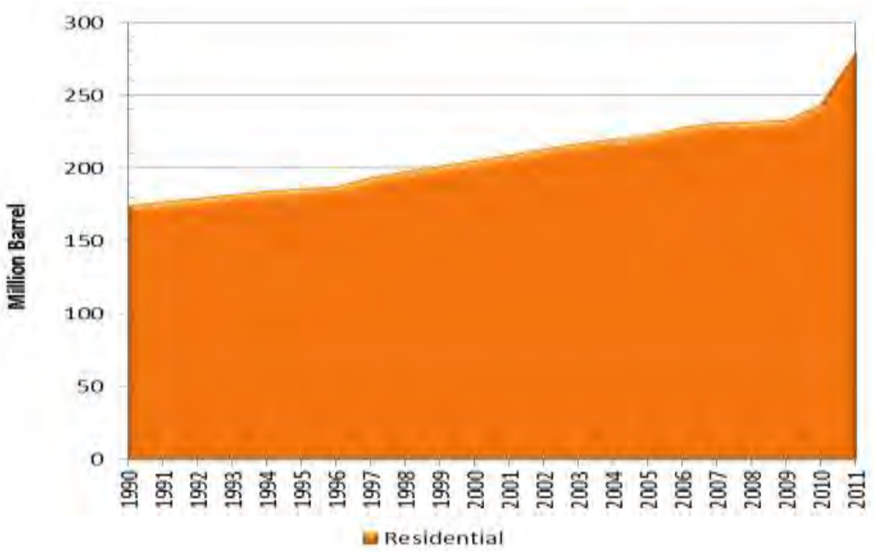
(*RPOILMt*), population (*JRT*), and the biomass consumption in the previous period (*REBIOt(-1)*).

Table 4.5 Factors Affecting Biomass Consumption in Residential Sector

Endogenous	Exogenous	Coefficient	Std. Error	t-Statistic	Prob.	R^2
REBIOT	C	-142184.2000	29048.9200	-4.8946	0.0000 *	0.9340
	POPt	1.3926	0.0849	16.3941	0.0000 *	

*) Significant at α = 5%
Source: processed data

Chart 4.6 Biomass Consumption in Residential Sector of the period 1990-2011



Source: processed data

At first, economic development will encourage developing countries to reduce their use of biomass. However, empirical result on Table 4.5 shows that GDP per capita has no significant correlation with biomass consumption, so it was excluded from the regression because biomass is consumed only on certain condition and situation. Biomass in the form of firewood and charcoal are still widely used in rural households which have low income and difficulties to obtain other kind of energy, making the consumption of biomass affected by previous behavior and condition. The increasing household that mostly occurs in urban areas (BPPT, 2012) reduces biomass consumption and increases the use of fossil fuel.

The price of kerosene has negative relationship and significant correlation with the consumption of biomass. The increasing price of kerosene will reduce the consumption of biomass. This condition does not fit Theory of Demand, wherein the increase of other energy price should increase biomass consumption.

The result of R-square test on *REBIOt* is 97.2 percent, indicating that all exogenous variables in the model can jointly explain biomass consumption in residential sector and the rest is explained by other factors.

4.1.1.6 Geothermal and Hydropower Consumption

Ministry of Energy and Mineral Resources (2010) reported that geothermal potential in Indonesia had reached 29.04 GW or about 30-40 percent of the world's geothermal potential, scattered along the path of volcanic at western part of Sumatra, Java, Bali, Nusa Tenggara, Maluku, and Sulawesi. Geothermal exploration and development activities in Indonesia have grown since 1972. But as of today, only 4 percent of the geothermal potential has been developed and utilized to generate electricity. In 2011, 1.16 GW of the installed capacity can produce 3.56 GWh of electricity, or equivalent to 16.5 million BOE, from a geothermal power plant.

Chart 4.7 Geothermal Consumption in Electricity Generation Sector for period 1990-2011

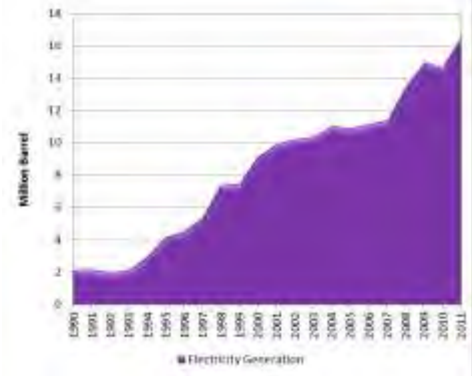
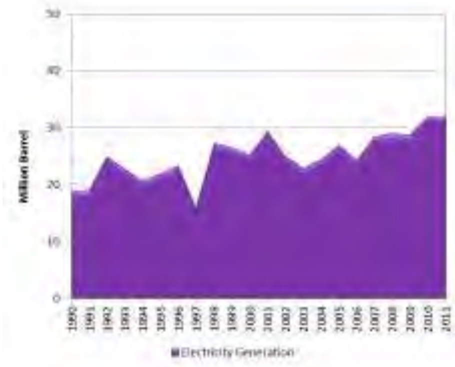


Chart 4.8 Hydropower Consumption in Electricity Generation Sector for period 1990-2011



Source: processed data

Hydropower is a natural resource that is widely used for electricity generation, both for large scales (above 10 MW per site) and micro scale (less than 10 MW). Hydropower potential spreads evenly in many regions in Indonesia. However, only 6.65 GW has been developed or only in a share of 4 percent of national primary energy mix.

Table 4.5 shows the estimation result of geothermal consumption (*EGGTt*) and hydropower consumption (*EGHYt*) in electricity generation sector, which depends on its price and supply (*IPGTt*, *IPHYTt*). Both energy sources are non-exportable and are clean energy sources.

Table 4.6 Factors Affecting Geothermal and Hydropower Consumption in Electricity Generation Sector

No.	Endogenous	Exogenous	Coefficient	Std. Error	t-Statistic	Prob.	R^2
a	EGGTT	C	0.1107	0.1363	0.8122	0.4171	1.0000
		IPGTT	1.0000	0.0000	37671.4200	0.0000 *	
b	EGHYT	C	2002.2060	4264.9870	0.4695	0.6390	0.7894
		RPHYT	0.0479	0.0221	2.1696	0.0306 *	
		IPHYTT	0.8164	0.1724	4.7360	0.0000 *	

*) Significant at $\alpha = 5\%$

Source: data processed

Geothermal development is strongly influenced by the geographical conditions, investment, regulation, human resources, and economic evaluation of its selling price to PT. PLN. High capital investment for exploration, drilling, and development activities of about 1.5 million US$ per MW (Mitsubishi and Fuji Electric in Ashat, 2013) are the constraints on developing this project. Furthermore, the high price of electricity from geothermal plant compared to the price of electricity from coal, gas, and subsidized oil fuel causes the geothermal industry become undeveloped.

In order to encourage the utilization of geothermal, the government has issued several regulations, such as Ministry Regulation MoEMR No.4/2012 on Electricity Purchase Price by PT. PLN (Persero) from Small and Medium Scale Renewable Energy Power Plant and Excess Power, Ministry Regulation MoEMR No. 22/2012 in Assignment to PT. PLN to Purchase Electricity from Geothermal Power Plant (PLTP) and Geothermal Power Purchase Benchmark Price by PT. PLN (Persero) controlling the Feed In Tariff (FIT) mechanism. The FIT mechanism is determined with consideration of energy resource availability, environment capacity, and economic. To date, the tariff is applied in a range of 10-18 cent US$/kWh.

The result of R-square test on *EGHYt* is 78.9 percent, indicating that all exogenous variables in the model can jointly explain the hydropower consumption and the rest is explained by other factors, while the consumption of geothermal is able to be explained precisely by its supply.

4.1.2. Economic Output Block

Economic growth is one of the indicators of nation's success in economic development (Todaro dan Smith, 2006), it relates to growth in the output of the economy as a whole. Chart 1.1 shows that during 1990-2011 period GDP growth reached 4.9 percent. In 1998 Indonesia's GDP was decrease in 5 percent due to economic crisis and gradually increase in the next year to 5.3 percent per year.

Using the hypothesis that economic growth is determinant factor increased energy consumption through sectoral GDP. This study formulated the effects of GDP on energy supply and demand directly or indirectly and vice versa

Table 4.7 Factors Affecting Disaggregate Sectoral GDP

No.	Endogen	Exogen	Coefficient	Std. Error	t-Statistic	Prob.	R^2	Dw
a	COMP	C	11654,7800	22404,6600	0,5202	0,6032	0,9711	2,1120
		COMPT(-1)	1,0643	0,0421	25,2880	0,0000 *		
b	EGPT	C	-51,6682	43,3672	-1,1914	0,2342	0,9993	2,3200
		EGPT(-1)	1,0738	0,0064	167,6750	0,0000 *		
c	INDPT	C	73038,9900	11882,8900	6,1466	0,0000 *	0,9936	1,3381
		SKBRT	-2208,4970	375,0894	-5,8879	0,0000 *		
		INDPT(-1)	0,8858	0,1008	8,7901	0,0000 *		
d	OCPT	C	166369,4000	66597,7100	2,4981	0,0129 *	0,7393	2,4124
		SKBRT	-3554,6610	1437,6480	-2,4726	0,0138 *		
		EXCHT	-6,9103	2,8636	-2,4132	0,0162 *		
		OCPT(-1)	0,8933	0,1288	6,9358	0,0000 *		
e	TRPT	C	7637,9330	1805,1710	4,2311	0,0000 *	0,9927	1,6113
		SKBRT	-315,1915	57,2864	-5,5020	0,0000 *		
		TRPT(-1)	0,9879	0,0244	40,4716	0,0000 *		

*) Significant at $\alpha = 5\%$

Source: data processed

The estimation result of economic output in Table 4.5 shows that sectoral GDP is depends on interest rate (*SKBRt*), exchange rate (*EXCHt*) and the GDP of the previous period. Total GDP (*PDBt*) is calculated as an identity equation from five economic sectors (*COMPt, EGPt, INDPt, OCPt, TRPt*).

a. GDP of Commercial Sector (*COMPt*)

Table 4.7 point a shows that GDP of commercial sector (*COMPt*) is affected only by GPD of the previous period (*COMPt(-1)*). With the R-square value of 78.9 percent, it indicates that all exogenous variables in the model can jointly explain the GDP of commercial sector and the rest is explained by other factors.

b. GDP of Electricity Generation Sector (*EGPt*)

Table 4.7 point b shows that GDP of electricity generation sector (*EGPt*) is affected only by GPD of the previous period (*EGPt(-1)*). With the R-square value of 99.9 percent, it indicates that all exogenous variables in the model can jointly explain the GDP of commercial sector and the rest is explained by other factors.

c. GDP of Industrial Sector (*INDPt*)

Table 4.7 point c shows that GDP of industrial sector (*INDPt*) is affected by interest rate (*SKBRt*) and GDP of the previous period (*INDPt(-1)*). Interest rate has negative relationship and significant correlation with GDP of industrial sector. The smaller interest rate, the more investment will be spent in industrial sector and the more output will be produced. R-square value of 99.4 percent indicates that all exogenous variables in the model can jointly explain the GDP of industrial sector and the rest is explained by other factors.

d. GDP of Other Sector (*OCPt*)

Table 4.7 point d shows that GDP of other sector (*OCPt*) is affected by interest rate (*SKBRt*), exchange rate (*EXCHt*), and GDP of the previous period (*OCPt(-1)*). Interest rate and exchange rate has negative relation and significant correlation with GDP of other sector. R-square value of 73.9 percent indicates that all exogenous variables in the model can jointly explain the GDP of other sector and the rest of it is explained by other factors.

e. GDP of Transportation Sector (*TRPt*)

GDP of transportation sector is directly related to the economic activities in transportation, such as land transportation, railway transportation, sea transportation, river and lake crossing transportation (ASDP), air transportation, and their support services.

Table 4.7 point e shows that the GDP of transportation sector (*TRPt*) is affected by interest rate (*SKBRt*) and GDP of the previous period (*TRPt(-1)*), with the following explanation.

Revenue of transportation sector derives from parking retribution and traffic control, public transport ticket, joint public-private project, also vehicle tax and fee (GTZ, 2010). Interest rate has negative relationship and significant correlation with GDP of transportation sector. Smaller interest rate will induce the consumers to own private vehicle that will increase vehicle tax and parking retribution, thus increasing the revenue of transportation sector. Similar response will be obtained by capital investment at private sector developing transportation project if the interest rate gets smaller.

The R-square value of 99.3 percent indicates that all exogenous variables in the model can jointly explain the GDP of transportation sector and the rest of it is explained by other factors.

4.2. Hypotheses Analysis

Using the statistical result and descriptive analysis in the previous section, this section will discuss hypotheses analysis to answer the research problem. It is in accord with the equation (2-12) which states that import is defined as a condition that occurs when consumption exceeds production and stocks. Policy of petroleum import in Indonesia consists of crude oil and oil fuel import. Based on the empirical result at Table 4.1, it is suggested that the consumption of oil fuel depends on the price of oil fuel, price of gas, number of residence, sectoral GDP, GDP per capita, number of vehicle, interest rate, energy diversification, and consumption of the previous period. Thus, the equation of oil fuel import is defined as:

Oil fuel import (*IMPPt*) = consumption (*FCOLt*) - production (*YBBMt*)

IMPPt = f {price of oil fuel, price of gas, number of residence, sectoral GDP, GDP per capita, number of vehicle, interest rate, energy diversification, and consumption of the previous period} – YBBMt .... (4.1)

Meanwhile, crude oil consumption is defined as an input for domestic refinery, thus the equation can be written as:

Crude oil import (*IMCRt*) = crude oil consumption or equals refinery capacity (*RFCRt*) – crude oil production (*IPOLt*) .... (4.2)

a. GDP and Oil Import

The empirical result on Table 4.1 shows that the disaggregated sector energy users on oil fuel consumption may responds quite differently in each sectors. This evidence is consistent with the analysis from Barsky and Kilian (2002) on disaggregated data of energy price shock and real GDP.

The result of t-test on Table 4.1 confirms that exogenous variable of GDP at the oil fuel consumption has the expected positive sign and is statistically significant at the dominant sector energy users consuming oil fuel. The report estimates p-value of GDP in oil fuel consumption at transportation (*TROLt*) and residential (*REOLt*) sector are below the significance level (α) of 0.05, those are 0.0140 and 0.0447 respectively.

The increase of Rp. 1,- in income per capita at transportation sector will translate into an increasing oil fuel consumption by 6,505 BOE, as a result of the increasing number of vehicles by 6 percent per year and the increasing mobility activities to support economic growth (Golshan *et al.*, 2013). Meanwhile, the increase of Rp. 1,- in income per capita at residential sector will reduce the consumption of oil fuel by 2,512 BOE because the society will switch to a cleaner, greener, and more modern energy.

Consistent with the evidence on GDP and the dominant type of energy, Table 4.2, Table 4.3, and Table 4.4 confirm that GDP is statistically significant at disaggregated level of coal consumption in electricity generation sector, gas consumption in industrial sector, and electricity consumption in commercial sector.

Using equation (4.1) and the estimation result on Table 4.1, the increase in oil fuel consumption as a result of the increase in GDP, *cateris paribus*, will increase the amount of oil fuel import. It can be concluded that the null hypothesis that there is no correlation between GDP and oil import through oil fuel consumption can be rejected. The result supports the research conducted by Royfaizal (2008) and Ziramba (2010) which stated that there is a relationship between GDP and oil import requirement. It also provides more detail evidence at disaggregated level that sectoral GDP will determine the consumption of oil fuel only in economic sector which consumes more oil, such as transportation (Lestari and Adam, 2008) and residential sector.

This evidence provides a substantial contribution on how GDP will affect energy consumption at disaggregated level while supporting the previous evidence in aggregated level conducted by Apergis and Danuletiu (2012), Elinur (2012), Adebola (2011), Lau *et al*. (2011), Binh (2011), Chary and Bohara (2010), Siddiqui (2010), Imran and Siddiqui (2010), Ghosh (2009), Khan and Qayyum (2007), Ho and Siu (2007), Lee and Chang (2007), Beaudreau (2005), Santosa and Yudiartono (2005), Oh and Lee (2004), Ghali and El-Sakka (2004), Wolde-Rufael (2004) and Stern (2000).

b. Subsidized Domestic Oil Price and Oil Import

The result of t-test on Table 4.1 confirms that exogenous variable of oil fuel price at the consumption of domestic oil fuel has the expected negative sign and is statistically significant in all sector energy users except electricity generation and residential sector. The report estimates p-value of oil fuel price in oil fuel consumption is below the significance level (α) of 0.05, which means that price of oil fuel is statistically significant to the consumption of oil fuel. Positive sign on price of oil fuel in electricity generation was caused by oil fuel subsidies, while in residential sector may caused by conversion program from kerosene to LPG.

This result shows that the rise of oil fuel price will significantly affect transportation sector as the largest oil fuel user (63 percent of total oil demand). The regression result on Table 4.1 shows that the increase of gasoline price by Rp. 1,- will reduce the consumption of oil in transportation sector by 89 BOE. When the gasoline price increases from Rp. 4,500/liter to Rp. 6,500/liter, it will reduce the consumption to 178 thousand BOE or 28 million kiloliters. Meanwhile, oil fuel consumption in industrial, commercial, and other sector will reduce only in small amount of 42 BOE, 4 BOE, and 6 BOE respectively.

Using the equation (4.1) and the estimation result on Table 4.1, the decreasing oil fuel consumption as a result of the increasing oil fuel price, *cateris paribus*, will reduce the amount of oil fuel import. It can be concluded that the null hypothesis that there is no correlation between price of oil fuel and oil import through oil fuel consumption can be rejected.

This evidence provides quantitative description of the role of the subsidized oil fuel price to the oil fuel consumption on disaggregated level. Moreover, it provides additional empirical result from the previous researches that the reduced oil fuel demand due to the increasing oil fuel price (Matheny, 2010; Kirana, 2005;

Marks, 2003; and Lewis, 1993) can occur in the absence of government policy intervention, such as subsidies and energy conversion program.

c. International Oil Price and Oil Import

International oil price has been increasing for years. The rise in oil prices benefits oil-exporting countries as a result of high oil revenue. On the contrary, based on United Nation Conference on Trade and Development (UNCTAD) report, Tefera *et al.* (2012) explained that it adversely affects oil-importing countries, although the level of the impact varies depending on the degree to which they are net importers and the oil intensity of their economies.

The result of t-test on Table 4.1 confirms that the exogenous variable of international oil price (POILWDt) is excluded from the oil fuel consumption model in all sector energy users because it has the p-value above the significance level (α) of 0.05. It can be concluded that the null hypothesis that there is no correlation between international oil price and oil import through oil fuel consumption cannot be rejected.

This evidence provides quantitative description on disaggregated level that the international oil price has positive relationship and no significant correlation with oil fuel consumption. Notwithstanding, the increasing international oil price will be followed by the increasing oil import due to oil price subsidies that leads to the increasing oil consumption. This evidence strengthens the report from IMF (2009) and Tefera (2012) that to the countries with oil fuel subsidies, oil price shock will not affect oil fuel consumption, but it will increase oil import.

Oil fuel subsidy improves the consumption of oil fuel in all economics sectors. Oil fuel subsidy is defined as the difference between reference oil fuel price and retail oil fuel price. Reference oil fuel price is calculated based on the Mid Oil Platt Singapore (MOPS) plus distribution cost and margins, while retail oil fuel price is defined as the retail selling price per liter of oil fuel in domestic area. Along 2012, the retail oil fuel price is Rp. 4.500/liter, while the reference oil fuel price is Rp. 8.400/liter at international oil price of US$ 105/barrel.

The increasing international oil price has a negative impact on the economic growth of the oil-importing countries. Surjadi (2006) explained the effect of increasing oil price to the economy by changing the nations' balance of payments and their exchange rates. Net oil importer will have a deficit balance of payment and depreciated exchange rate. It will result in more expensive imports with the reduction of export and real national income. Without the changes in central bank's and monetary policies, dollar tends to be more expensive. Oil subsidy scheme increases government expenditure and reduces government saving. Hence, total investment falls.

Nevertheless, the impact of oil price shock moment to the economy (Backus and Crucini, 2000; Finn, 2000) and energy consumption (Kilian, 2008) is not analyzed in this research. Referring to the research of Barsky and Kilian (2002), oil price shock may respond quite differently at disaggregated level (Lee and Ni, 2002; Herrera *et al.*, 2007).

d. Crude Oil Production and Oil Import

Models on the equation (3.26) until (3.28) are generated based on historical data, showing that crude oil production will determine oil import through the import of crude oil. The amount of crude oil import as refinery input is determined by oil refinery capacity and specification, also domestic crude oil production excluding export. The amount of oil fuel import is determined by the refinery capacity to produce petroleum product and oil fuel demand.

This model explains the condition before 2004 when the domestic crude oil production was higher than oil fuel demand, yet the limit of refinery capacity and specification increased oil import in amout of 20-30 percent.

To answer the research question and hypothesis, regression analysis is made to determine factors affecting crude oil and oil fuel import, as the following result:

Table 4.8 Factors Affecting Crude Oil and Oil Fuel Import

Endogenous	Exogenous	Coefficient	Std. Error	t-Statistic	Prob.	R^2
IMCRT	C	91666.9300	60973.7300	1.5034	0.1511	0.8910
	REFCRT	0.6377	0.1150	5.5474	0.0000 *	
	IPOLT	-0.3957	0.0682	-5.8031	0.0000 *	
	POILWDT	-0.0685	0.0212	-3.2312	0.0049 *	
IMPPT	C	-5430.1160	43692.0400	-0.1243	0.9026	0.9215
	FCOLT	0.6473	0.1860	3.4803	0.0029 *	
	YBBMT	-0.6440	0.2731	-2.3581	0.0306 *	
	PDBT	0.0226	0.0250	0.9052	0.3780 **	

*) Significant at $\alpha = 5\%$
Source: processed data

Table 4.8 shows that crude oil production (*IPOLt*) has no significant correlation with oil fuel import (*IMPPt*), thus dropped from the equation. But it has negative relationship and significant correlation with crude oil import (*IMCRt*), with p-value above the significance level of 0.05.

Using the equation (4.2) and the estimation result on Table 4.8, the increasing crude oil production, *cateris paribus*, will reduce oil import through the reduction of crude oil import. It can be concluded that the null hypothesis that there is no correlation between crude oil production and oil import can be rejected.

The regression result on Table 4.8 is used to analyze the correlation between variables but it cannot be used to estimate the effect of production reduction on crude oil import. The estimation of crude oil import is calculated as the difference between crude oil consumption and production, as shown on identity equation (4.2).

This result strengthens the previous research by Kirana (2005) in analysis of Indonesia's crude oil production and import of the period from 1980 to 2003. Similar to Pablo (2010) in the analysis of crude oil reserves, production, and import in United States. The declining crude oil reserves and production will increase oil import requirement.

e. Refinery Efficiency and Oil Import

The analysis of historical data on the equation (3.25) until (3.28) shows that the increasing refinery capacity will increase crude oil demand as refinery input. As a result, the petroleum product resulted from refinery process will increase proportionally while reducing the import of oil fuel, *cateris paribus*. Nevertheless, the addition of crude oil as a refinery input may cause the increase in crude oil import.

This condition is strengthed by empirical regression result on Table 4.8, wherein the refinery capacity (*RFCRt*) has p-value below the significance level of 0.05. It means that oil refinery capacity individually has significant correlation and positive relationship with crude oil import (*IMCRt*). Oil refinery efficiency at downstream sector in term of refinery output or petroleum product (*YBBMT*) has negative relationship and significant correlation with oil fuel import (*IMPPt*).

The equation (4.1) and (4.2) show that the increase in oil refinery efficiency, *cateris paribus*, will increase total oil import through crude oil import but decrease oil fuel import. It can be concluded that the null hypothesis that there is no correlation between oil refinery efficiency and oil import can be rejected.

Similar to the regression of crude oil import, the regression of oil fuel import will be used to analyze correlation between variables. The estimation of oil fuel import is calculated as the difference between oil fuel consumption and production, as shown on identity equation (4.2).

Historical data from MoEMR showed that Indonesia has ten active oil refineries with the total capacities of 1,156 BOPD, but only 879 BOPD can be operated and only 20 percent of domestic crude oil production can be refined in 2011. Refinery is a long term industry and is influenced by the type of crude oil. To increase oil refinery efficiency, conversion investment in new refineries and capacity creep is needed. Conversion investment is modifying existing capacity to cope with new demand (lighter products) or new environmental restrictions on products.

Singapore, for example, has a large number of refineries and becomes the country with the largest oil production in Asia, although it does not have the potential oil resources. Developing domestic refinery industry will create value added in refinery sector, reduce unemployment, and create other multiplier effect to the industry and community near the refinery plant.

f. Energy Diversification and Oil Import

Energy diversification is an effort to shift energy use from oil into non-oil energy, such as gas and coal. The government's and community's success since 2005 in the conversion of kerosene to LPG needs to be continued and enhanced. The regression result on Table 4.1 shows that diversification has significant correlation and positive relationship with the consumption of oil fuel in residential and industrial sector.

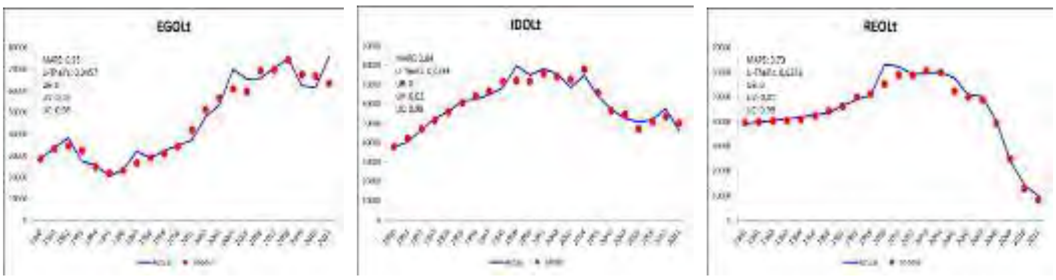
The result of t-test on the equation of oil fuel consumption in Table 4.1 confirms that the p-value of energy diversification in residential and industrial sector are smaller than α value of 0.05, which means the diversification variable individually has significant correlation with the consumption of oil fuel. Using the equation (4.1) and the regression result in Table 4.1, the reduction of oil fuel consumption as a result of oil fuel shifting or energy diversification will reduce the amount of oil fuel import. Thus, it can be concluded that the null hypothesis that there is no correlation between energy diversification and oil import through oil fuel consumption can be rejected.

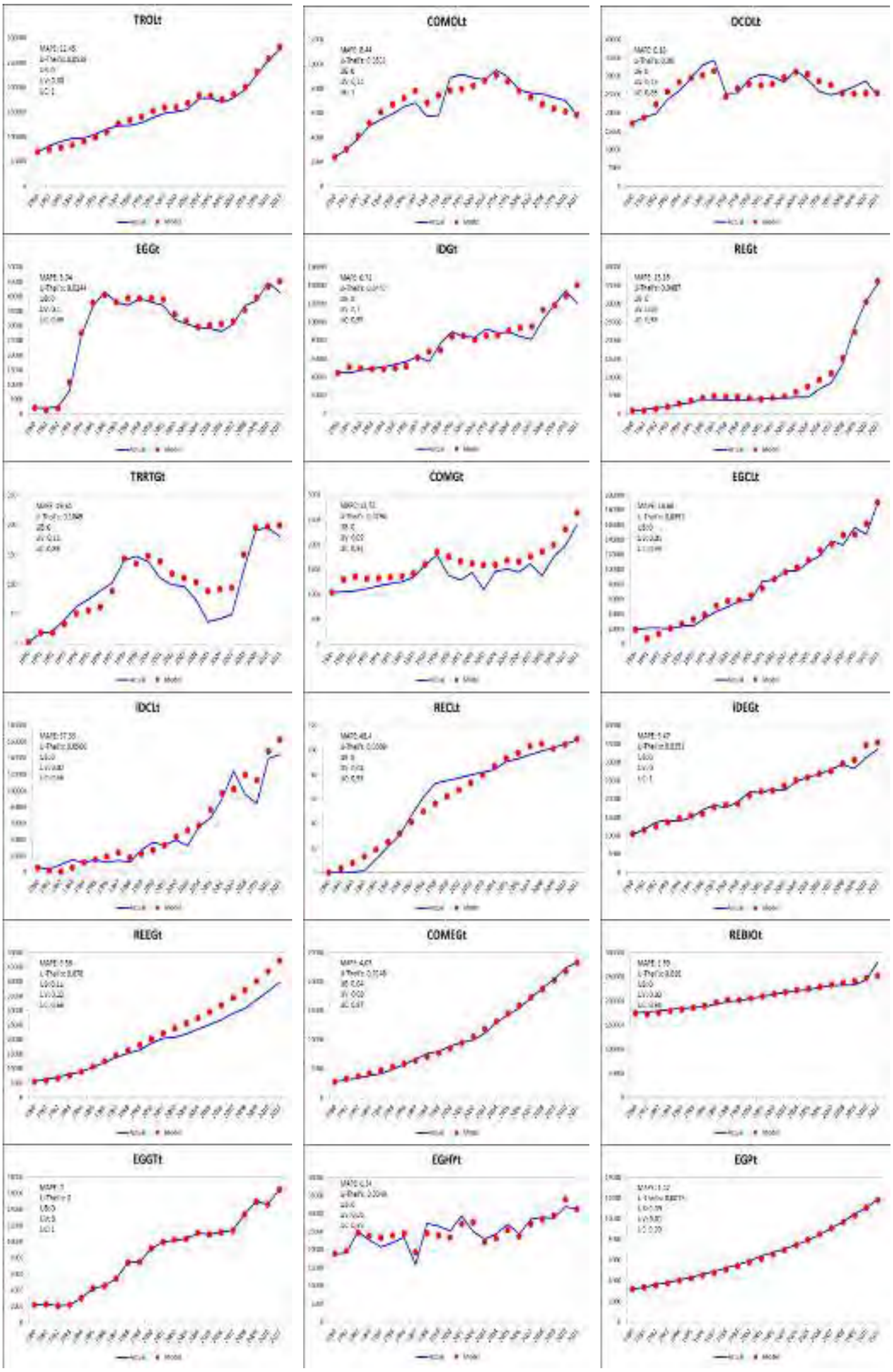
The increase of oil fuel shifting in residential sector by 1 percent has the potential to reduce kerosene consumption by 67.047 thousand BOE or equivalent to 11 million kiloliters. Similiar to the industrial sector, oil demand will be reduced by 74.994 thousand BOE or equivalent to 12 million kiloliters, while gas and coal demand will increase as a result of the diversification.

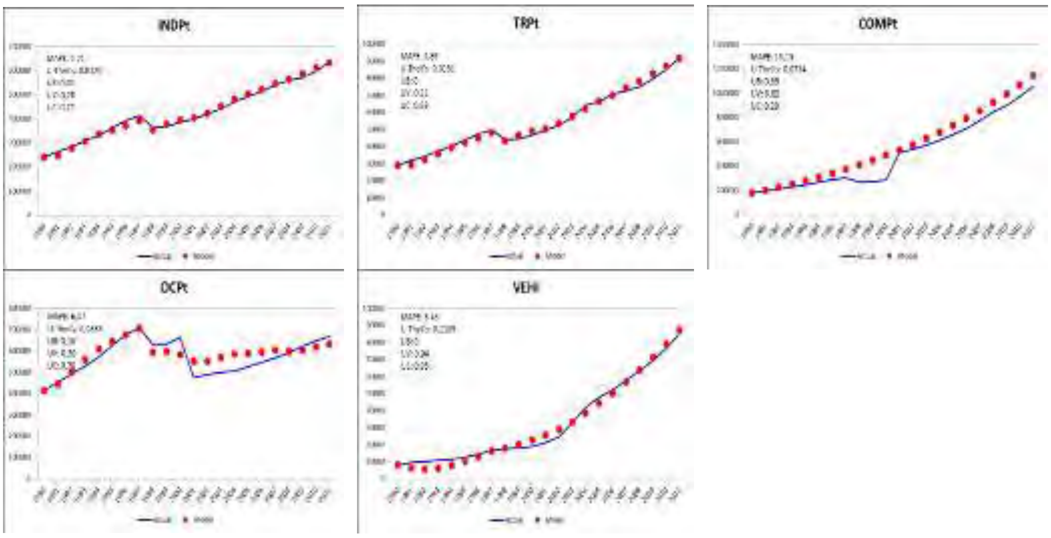
4.3. Model Validation Result

The models which are built based on historical period from 1990 to 2007 are validated by withholding four years of data (2008-2011) when specifying and estimating the model. This process generates an ex-post forecast to determine how well the models predicted the endogenous variables. The graphs of actual and fitted values of the sample period on 26 structural equations are shown in Chart 4.9, including the resulted validation indicators, i.e. MAPE, U-Theil's, bias proportion, variance and covariance structure.

Chart 4.9 Sample Period Performance (Actual and Model) on 26 Structural Equations




TROLt
COMOLt
DCOLt
EGGt
IDGt
REGt
TRRTGt
COMGt
EGCLt
IDCLt
RECLt
IDEGt
REEGt
COMEGt
REBIOt
EGGTt
EGHPt
EGPt



Source: processed data

These chart show that 24 out of 26 structural equations in the model have smaller MAPE values of 20 percent, indicating that the deviation between estimation and actual value is less than 20 percent with an average deviation of 7.4 percent. Meanwhile, the other 2 endogenous variables are coal consumption in industrial (IDCLt) and residential sector (RECLt) which have larger MAPE values of 48.4 and 67.3 percent respectively. The smaller forecast error value indicates the model’s reliability to predict.

The analysis based on U-Theil's test shows that all structural equations in the model have values smaller than 0.15, indicating that the model can be used for the better forecasting simulation analysis.

Small value of bias proportion (UB) below 0.2 indicates non systematic bias resulted from all equations, except the equation of GDP in commercial sector (COMPt) which has a UB value above 0.2. However, higher determination coefficient value (R-square) of COMPt (97.1 percent) indicates that all exogenous variables have been able to explain the GDP in commercial sector, so the revision of the equation will not be necessary.

Small value of variance proportion (UV) below 0.3 indicates that the models have been able to replicate the fluctuation pattern of the actual series. Finally, higher value of covariance proportion (UC) close to 1 indicates that the model is ideal for forecasting model.

Table 4.9 presents the validation result of energy balance model, illustrating the validation indicators on 26 structural equations in the model. This table suggests that the estimated model is good enough to provide an accurate estimation value. It also will be able to forecast and simulate policy alternatives both on historical simulation and forecasting period from 2012 to 2030.

Table 4.9 Validation Analysis of Structural Equations on Energy Balance Model

No	Endogenous Variable	Code	RMS Error	Mean Abs Error	Mean Abs. % Error	Bias (UB)	Variance (UV)	Covar (UV)	U
1	Consumption of oil fuel at Electricity Generation sector	EGOLT	4,498.05	3,279.18	6.95	0.00	0.02	0.98	0.0457
2	Consumption of oil fuel at Industrial sector	IDOLT	2,943.78	2,355.11	3.84	0.00	0.02	0.98	0.0239
3	Consumption of oil fuel at Residential sector	REOLT	2,309.19	1,354.51	3.73	0.00	0.01	0.99	0.0248
4	Consumption of oil fuel at Transport sector	TROLT	16,284.91	15,561.51	12.45	0.00	0.00	1.00	0.0538
5	Consumption of oil fuel at Commercial sector	COMOLT	740.07	594.72	8.44	0.00	0.14	1.00	0.0531
6	Consumption of oil fuel at Other sector	OCOLT	1,979.96	1,682.38	6.18	0.00	0.15	0.85	0.0239
7	Consumption of gas at Electricity Generation sector	EGGT	1,600.13	1,295.16	8.04	0.00	0.01	0.99	0.0244
8	Consumption of gas at Industrial sector	IDGT	7,406.86	5,496.25	6.72	0.00	0.01	0.99	0.0447
9	Consumption of gas at Residential sector	REGT	1,206.00	848.81	13.18	0.00	0.02	0.98	0.0487
10	Consumption of gas at Transport sector	TRRTGT	23.57	17.92	19.64	0.00	0.11	0.89	0.1049
11	Consumption of gas at Commercial sector	COMGT	249.93	212.01	12.78	0.00	0.09	0.91	0.0794
12	Consumption of coal at Electricity Generation sector	EGCLT	7,473.66	5,995.19	18.68	0.00	0.01	0.99	0.0392
13	Consumption of coal at Industrial sector	IDCLT	12,454.91	9,579.75	67.33	0.00	0.02	0.98	0.0906
14	Consumption of coal at Residential sector	RECLT	7.43	6.07	48.40	0.00	0.04	0.95	0.0509
15	Consumption of electricity at Industrial sector	IDEGT	1,130.19	783.91	3.47	0.00	0.00	1.00	0.0251
16	Consumption of electricity at Residential sector	REEGT	3,715.87	2,755.25	9.56	0.11	0.22	0.66	0.0780
17	Consumption of electricity at Commercial sector	COMEGT	369.65	303.61	4.03	0.04	0.09	0.87	0.0148
18	Consumption of biomass at Residential sector	REBIOT	6,739.16	3,537.39	1.59	0.00	0.02	0.98	0.0160
19	Consumption of geothermal at Electricity Generation sector	EGGTT	0.22	0.18	0.00	0.00	0.00	1.00	0.0000
20	Consumption of hydropower at Electricity Generation sector	EGHYT	1,756.10	1,509.56	6.34	0.00	0.05	0.95	0.0348
21	GDP at Electricity Generation sector	EGPT	103.14	82.47	1.42	0.09	0.01	0.99	0.0073
22	GDP at Industrial sector	INDPT	10,550.19	8,988.45	2.21	0.01	0.28	0.71	0.0120
23	GDP at Transport sector	TRPT	1,753.20	1,452.50	2.89	0.00	0.31	0.69	0.0151
24	GDP at Commercial sector	COMPT	87,041.48	70,711.32	13.15	0.69	0.02	0.29	0.0724
25	GDP at Other sector	OCPT	44,608.56	35,924.27	6.17	0.10	0.20	0.70	0.0383
26	Number of vehicle	VEHI	8,309.35	7,735.02	6.43	0.00	0.04	0.95	0.1109

Source: processed data

4.4. Baseline Forecast

Prior to forecasting in ex-ante forecast period (2012-2030), the endogenous variables or structural equations were validated in ex-post forecast period (2008-2011). Forecasts of the model were conducted by stepwise autoregression (STEPAR) method, beginning with generating the estimation of exogenous explanatory variable using trend liner model followed by making the estimation of endogenous variables using the previous energy balance model.

This sub section will discuss the forecast of energy balance model by type of energy and sectoral energy users. Graphs will present yearly actual condition (from 1990 to 2011) and forecasted condition (from 2012 to 2030) based on estimation models. The estimations of external exogenous variables are presented in Appendix B1 to Appendix B4, while the estimations of endogenous variables are presented in Table 4.10 to Table 4.14.

Indonesia's energy supply and demand forecast presented on Table 4.10 shows that during the period from 2011 to 2030, energy consumption is expected to grow in average of 4.9 percent per year, increases from 1,502 million BOE in 2011 to 3,462 million BOE in 2030. The increase of energy consumption is slightly lower compared to GDP growth, indicating that the structural economic change is still in progress. Meanwhile, the GDP in commercial sector will increase rapidly and dominate the share of the total GDP, followed by GDP in industrial and other sector.

Table 4.10 Baseline Forecast of Energy Supply and Demand in 2011 and 2030

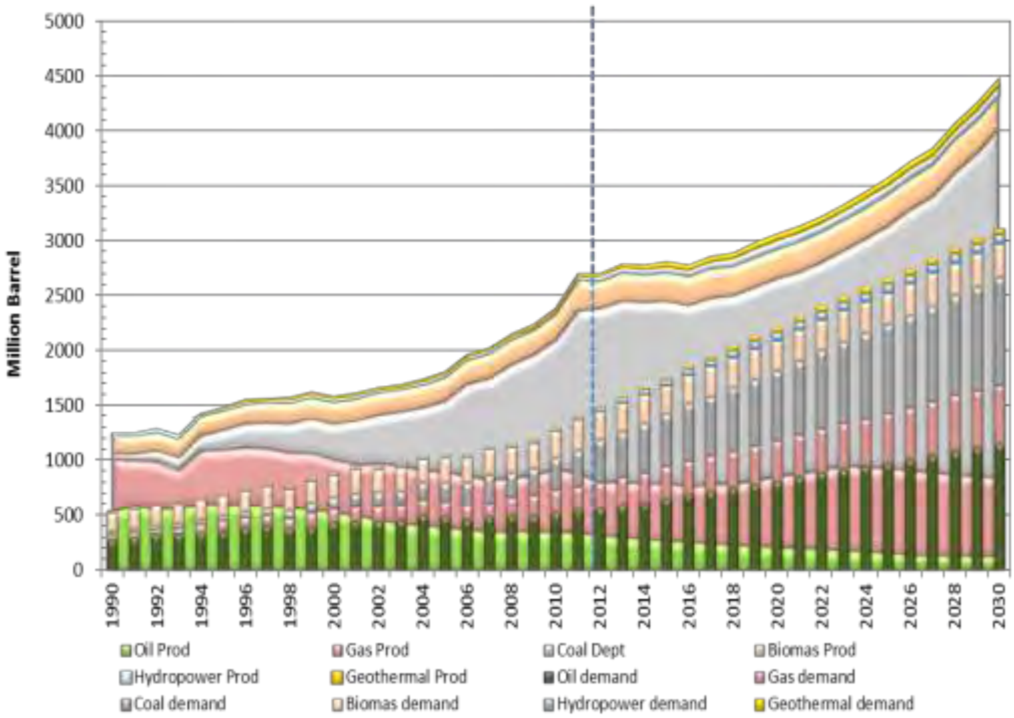
No	Variable name	Code	Unit	2011	2030	Annual growth (%)	Growth 1990-2010 (%)
1	Consumption of oil fuel at Electricity Generation sector	EGOLT	Thousand barrel	75,751	73,193	-0.1%	6.1%
2	Consumption of oil fuel at Industrial sector	IDOLT	Thousand barrel	45,951	72,884	2.5%	1.4%
3	Consumption of oil fuel at Residential sector	REOLT	Thousand barrel	10,027	6,049	-2.5%	-4.9%
4	Consumption of oil fuel at Transport sector	TROLT	Thousand barrel	277,170	806,318	5.8%	7.0%
5	Consumption of oil fuel at Commercial sector	COMOLT	Thousand barrel	5,817	1,431	-7.1%	5.5%
6	Consumption of oil fuel at Other sector	OCOLT	Thousand barrel	24,816	19,715	-1.2%	2.3%
7	Total of oil fuel consumption	FCOLT	Thousand barrel	439,532	979,589	4.3%	4.1%
8	Consumption of gas at Electricity Generation sector	EGGT	Thousand barrel	41,479	84,555	3.8%	25.2%
9	Consumption of gas at Industrial sector	IDGT	Thousand barrel	120,257	360,820	6.1%	5.4%
10	Consumption of gas at Residential sector	REGT	Thousand barrel	35,440	81,677	4.5%	20.2%
11	Consumption of gas at Transport sector	TRRTGT	Thousand barrel	181	250	1.7%	42.0%
12	Consumption of gas at Commercial sector	COMGT	Thousand barrel	2,402	12,531	9.1%	5.0%
13	Total of gas consumption	ECGT	Thousand barrel	199,759	539,834	5.4%	7.6%
14	Consumption of coal at Electricity Generation sector	EGCLT	Thousand barrel	189,498	529,991	5.6%	12.4%
15	Consumption of coal at Industrial sector	IDCLT	Thousand barrel	144,567	454,940	6.3%	24.2%
16	Consumption of coal at Residential sector	RECLT	Thousand barrel	108	240	4.3%	52.9%
17	Total of coal consumption	FCCLT	Thousand barrel	334,173	985,171	5.9%	13.7%
18	Consumption of electricity at Industrial sector	IDEGT	Thousand barrel	33,547	52,116	2.4%	5.9%
19	Consumption of electricity at Residential sector	REEGT	Thousand barrel	39,914	223,034	9.6%	9.9%
20	Consumption of electricity at Commercial sector	COMEGT	Thousand barrel	23,336	57,288	4.8%	10.7%
21	Total of electricity consumption	FCEGT	Thousand barrel	96,797	332,438	6.7%	8.2%
22	Consumption of biomass at Residential sector	REBIOT	Thousand barrel	280,171	303,901	0.5%	2.3%
23	Consumption of geothermal at Electricity Generation sector	EGGTT	Thousand barrel	16,494	60,000	7.4%	10.9%
24	Consumption of hydropower at Electricity Generation sector	EGHYT	Thousand barrel	31,269	86,503	5.7%	4.2%
25	Total of energy consumption	ECT	Thousand barrel	1,502,443	3,462,042	4.5%	4.9%
26	Refinery input	RFCRT	Thousand barrel	321,018	586,079	3.3%	0.8%
27	Refinerry output	OTPPT	Thousand barrel	341,384	553,550	2.7%	1.4%
28	Refinery production - oil fuel product	YBBMT	Thousand barrel	237,135	398,943	2.9%	1.2%
29	Refinery production - non-oil fuel product	YNBBMT	Thousand barrel	104,249	154,607	2.3%	2.4%
30	Import of crude oil	IMCRT	Thousand barrel	96,862	492,035	9.3%	4.8%
31	Import of oil fuel	IMPPT	Thousand barrel	172,113	580,646	6.8%	13.1%
32	Total of oil import	IMOLT	Thousand barrel	268,975	1,072,681	7.7%	7.5%
33	GDP at Electricity Generation sector	EGPT	Trillion Rupiah	11,959	43,833	7.1%	6.5%
34	GDP at Industrial sector	INDPT	Trillion Rupiah	634,247	1,018,624	2.5%	4.8%
35	GDP at Transport sector	TRPT	Trillion Rupiah	91,797	167,730	3.2%	5.7%
36	GDP at Commercial sector	COMPT	Trillion Rupiah	1,055,281	4,164,849	7.5%	9.7%
37	GDP at Other sector	OCPT	Trillion Rupiah	669,959	738,374	0.5%	2.7%
38	Total of GDP	PDBT	Trillion Rupiah	2,463,242	6,133,411	4.9%	4.9%
39	Total of oil import in value	IMV	Trillion Rupiah	263,077	1,277,067	9.3%	24.2%
40	Total enegry consumption at residential sector	REECT	Thousand barrel	365,660	614,901	2.8%	2.5%
41	Total enegry consumption at industrial sector	IDECT	Thousand barrel	344,322	940,761	5.5%	6.5%
42	Total enegry consumption at electricity generation sector	EGECT	Thousand barrel	354,491	854,241	4.7%	8.2%
43	Total enegry consumption at commercial sector	COMECT	Thousand barrel	31,555	71,250	4.4%	8.2%
44	Total enegry consumption at transport sector	TRECT	Thousand barrel	277,351	806,568	5.8%	7.0%
45	Export of crude oil	EXOLT	Thousand barrel	135,572	31,348	-7%	-3%
46	Export of natural gas	EXGT	Thousand barrel	240,622	168,166	-1.5%	0.3%
47	Export of coal	EXCLT	Thousand barrel	1,145,220	2,193,930	3.6%	24.2%
48	Number of vehicle	VEHI	Unit	85,601	261,296	6.1%	12.1%
49	Production of crude oil	IPOLT	Thousand barrel	335,041	131,898	-5.0%	-2.1%
50	Production of natural gas	IPGT	Thousand barrel	542,730	720,000	1.5%	1.3%
51	Production of coal	IPCLT	Thousand barrel	1,483,738	2,948,560	4.1%	18.6%
52	Production of geothermal	IPGTT	Thousand barrel	16,494	59,115	7.4%	10.9%
53	Production of hydropower	IPHYTT	Thousand barrel	31,269	97,645	6.7%	2.7%

Source: processed data

Chart 4.10 presents the trends of energy supply and demand per type of energy according to baseline scenario. The bar chart shows the quantity of energy demand and area chart shows the quantity of energy supply. It estimated that until 2030, Indonesia would still be a net oil importer but has not yet been a net energy importer. Fossil fuels such as oil, natural gas, and coal are predicted to dominate the energy mix in the future.

Chart 4.10 also presents that Indonesia has an abundant and varied energy resources, but they have not been fully utilized for domestic needs considering the next generation needs. Exploitation of coal as a non-renewable fossil fuel is shown to increase rapidly for export purpose. Meanwhile, the potential of renewable energy resources like geothermal and hydropower have not been optimally utilized.

Chart 4.10 Actual and Forecasted Primary Energy Supply and Demand of the period from 2011 to 2030

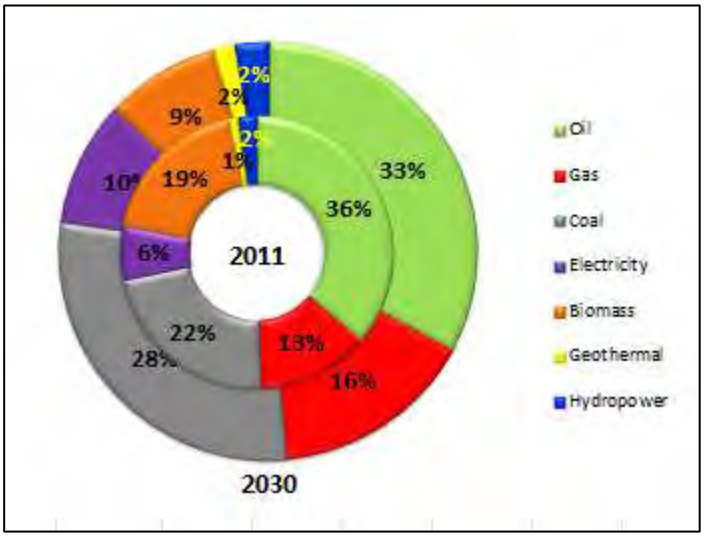


Source: processed data

a. Final Energy Demand based on Type of Energy

The consumption of oil fuel (gasoline, diesel oil, fuel oil, kerosene, and aviation fuel) is predicted to increase by 4.3 percent per year along with the growth of economic and population. It increases from 439 million barrels per year (BOPY) or 1,204 million barrels per days (BOPD) in 2011 to 979 million BOPY or 2,684 million BOPD in 2030. Despite the increasing demand, the consumption of oil fuel begins to be replaced by other types of energy, such as gas and coal in the long term. Thus, the contribution of oil fuel in total energy mix will decrease from 36 percent in 2011 to 33 percent in 2030.

Chart 4.11 Share of Final Energy Demand by Type of Energy in 2011 and 2030



Source: processed data

Along with the increasing international oil price, domestic energy demand, and environmental issue, the use of natural gas is also expected to grow rapidly. The consumption of gas is predicted to grow in average of 5.4 percent per year, from 200 million BOE in 2011 to 540 million BOE in 2030. The share of natural gas on total energy mix will increase from 13 percent in 2011 to 16 percent in 2030.

The contribution of coal in energy supply accelerates from 22 percent in 2011 to 28 percent in 2030. It is mainly used for power generation and heavy industry. Domestic coal demand is expected to grow in average of 5.9 percent per year, from 334 million BOE in 2011 to 985 million BOE in 2030.

Demand for electricity is projected to grow rapidly by 6.7 percent per year, increasing from 97 million BOE in 2011 to 332 million BOE in 2030 due to the increasing human living standards to apply more modern and cleaner technology.

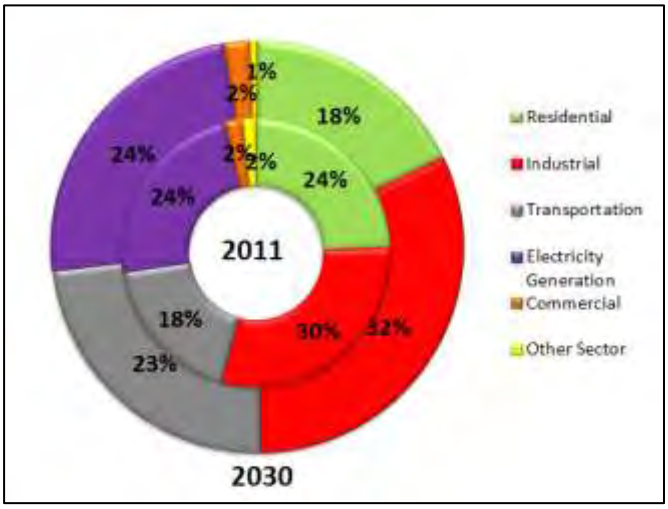
The role of traditional biomass in residential sector is predicted to shrink due to the increasing living standards, welfare, modernization, and environmental issues (Alikodra and Syaukani, 2004 in Widhiastuti, 2008). The contribution of traditional biomass in form of firewood in energy mix is projected to decrease from 19 percent in 2011 to 9 percent in 2030.

Inconsistency between policies (oil price subsidy and energy diversification) will lead to the rising oil fuel dependency, thus affect the undevelopment of other energy sources as shown in Chart 4.11. The contribution of renewable energy, such as geothermal and hydropower, was only 3 percent in 2011. Even though the feed-in tariff policy for the use of geothermal and hydropower to generate electricity is applied, it only increases the share of renewable energy to 5 percent in 2030.

b. Sectoral Energy Demand

The share of energy consumption in industrial sector will increase from 30 percent in 2011 to 32 percent in 2030. The changing role of firewood in residential sector due to the increasing purchasing power will reduce the share of energy consumption in residential sector from 24 percent in 2011 to 18 percent in 2030. On the other hand, the share of energy consumption in electricity generation will rise steadily by 24 percent. The largest increase in energy consumption is in transportation sector, from 18 percent in 2011 to 23 percent in 2030.

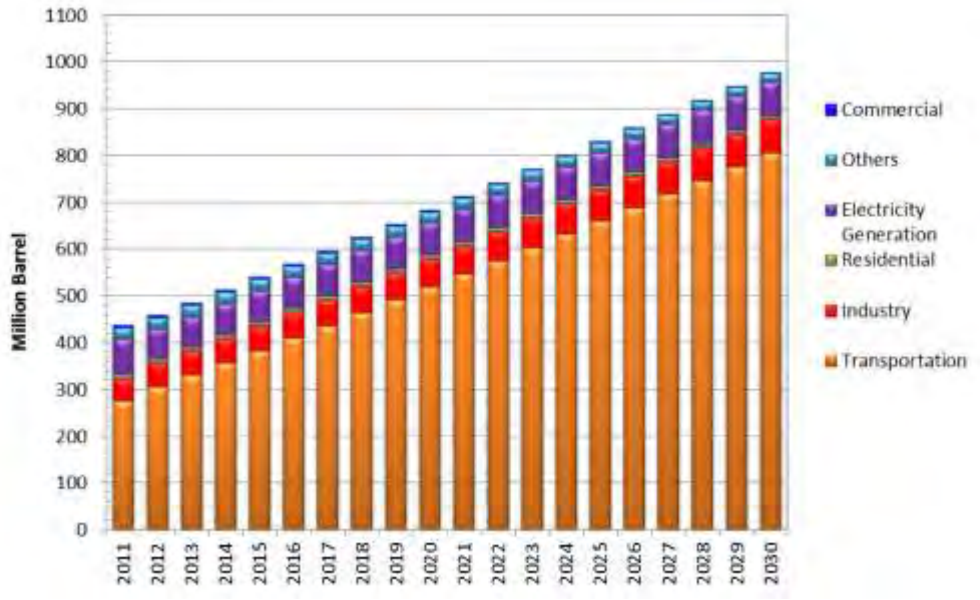
Chart 4.12 Share of Sectoral Energy Demand in 2011 and 2030



Source: processed data

Sectoral oil demand is still dominated by transportation sector in a share of 82 percent, followed by industrial and electricity generation sector by 7 percent each, other sector by 3 percent, commercial and residential sector by 1 percent each, as shown on Chart 4.13. Oil fuel consumption in transportation sector is predicted to increase from 277 million BOE in 2011 to 806 million BOE in 2030 or increase for about 5.8 percent per year. This condition will be supported by the increasing number of vehicle, passengers' movement, and population. The increasing number of vehicle both passenger car and private car are 6.1 percent annually.

Chart 4.13 Baseline Forecast of Sectoral Energy Demand



Source: processed data

Growth of oil fuel consumption in electricity generation will drop to 0.1 percent per year from the previous period by 6.1 percent per year. Electrical power is produced largely from thermal power plants from gas and coal, thus predicted to increase in average of 3.8 percent and 5.6 percent respectively. Oil fuel is still required as energy source to generate electricity during peak hours to support the operation of power generations. Utilization of renewable energy such as geothermal and hydropower is expected to rise in average of 7.4 percent and 5.7 percent per year.

c. Energy Supply

The baseline forecast on Chart 4.10 shows that Indonesia's primary energy supply will continue to be dominated by fossil fuels, such as coal, natural gas, and petroleum. The total primary energy production in 2030 is amounted to 4,462 million BOE, still higher than its consumption. It indicates that, in terms of volume unit, Indonesia has not yet become a net energy importer until 2030.

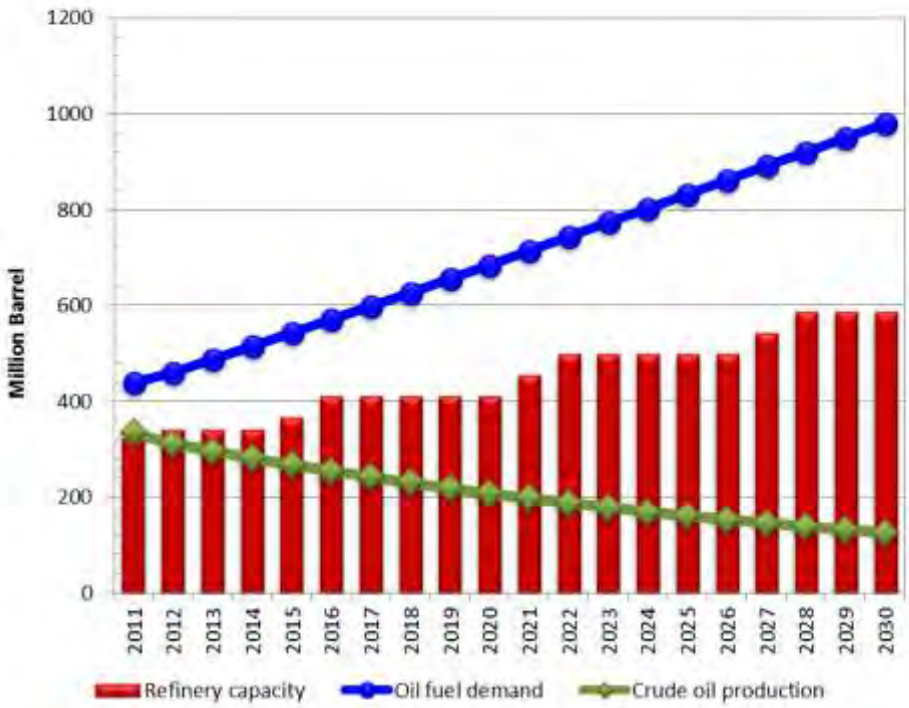
Although growing rapidly, the contribution of new and renewable energy (EBT) in the future is still relatively small compared to the share of fossil fuel. Baseline forecast on Chart 4.11 and Table 4.11 presents that the energy supply mix in 2030 will be dominated by coal at 73 percent, 19 percent of natural gas, 3 percent of oil, and 5 percent of renewable energy.

Of the total energy produced, 77 percent of coals and 44 percent of gas are for exports. Meanwhile, 84 percent of crude oil and 47 percent of oil fuel derive from imports. In terms of price, there is a high disparity between imported and exported energy. Coal and gas are exported at a price of 5.6 and 1.5 times cheaper than the price of imported oil.

Coal and gas production will grow by an average of 4.1 percent and 1.5 percent annually. Meanwhile, crude oil production will decline by 5 percent per year due to the continuous exploitation on some mature fields (more than 30 years). This condition will lead to the expantion of oil reserves both domestically and undomestically to overcome the oil shortage.

Chart 4.14 shows that the declining domestic crude oil production and the increasing refinery capacity become major factors that lead to the increasing crude oil import as a refinery input. Crude oil imports are expected to increase from 97 million BOE in 2011 to 492 million BOE in 2030, or grow in average of 9.3 percent per year. In 2030, it is estimated that 84 percent of domestic refinery needs will be derived from imports.

Chart 4.14 Baseline Forecast of Oil Supply



Source: processed data

Along with energy consumption that continuously increases, the need for energy transformation also increases, in this case is the oil refinery transformation. The increasing refinery capacity is expected to occur in every five years through new refinery additions (Appendix B.3) that will increase crude oil demand as an input.

Chart 4.14 also shows that oil imports are expected to increase by 6.8 percent per year as a result of the increasing oil fuel consumption which does not keep pace with the increasing refinery capacity to produce petroleum product. It is estimated that 54 percent of domestic oil fuel needs will be obtained from imports in 2030.

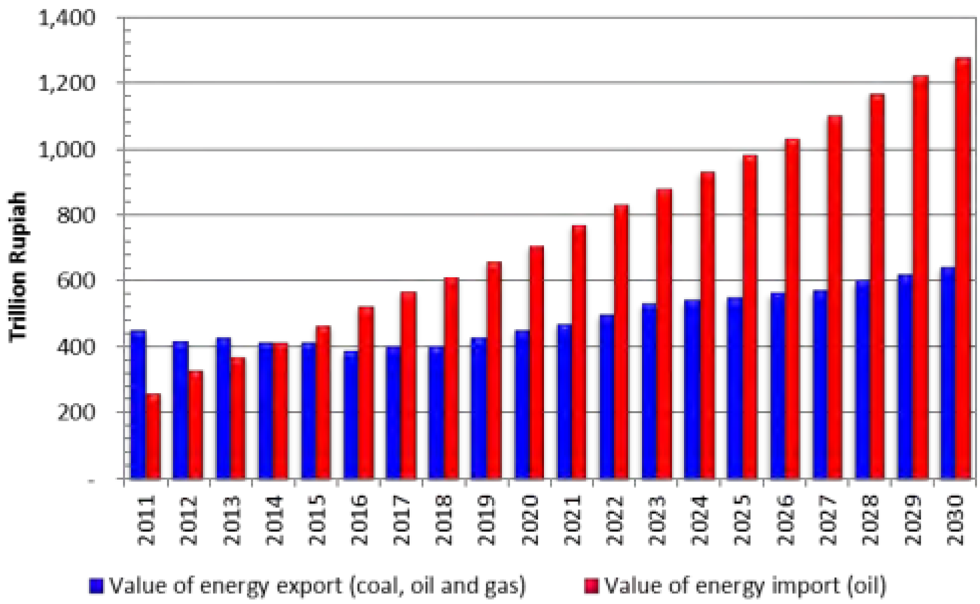
Total oil imports in 2030 are estimated at 1,072 million BOE, comprises 492 million BOE of crude oil imports (84 percent of refinery capacity) and 580 million BOE of oil fuel imports (54 percent of oil fuel demand). It is estimated that total oil imports in 2030 will increase by 3.4 times its amount in 2011.

Baseline scenario assumes international oil price will increase in average of 1.04 percent per year until 2030. The value of oil import will reach Rp 1,277 trillion or increase 3.6 times from its amount in 2011, reaching 21 percent of total GDP, while in 2011 it was only 11 percent of the total GDP.

The important finding of this baseline forecast suggests: (1) Indonesia's energy consumption is not adapted to its potential. Indonesia has abundant energy resources both in renewable and non renewable energy, but the most widely consumed energy is oil, in which 80 percent of it is obtained from imports. It is predicted that only 4 percent of renewable energy potential will be developed while the rest of it will be ignored. At the current production rate, Indonesia's reserves for coal, natural gas, and crude oil are estimated to last for 82 years, 32 years, and 10 years respectively.

Unfortunately, the production of coal and natural gas are intended for export market at lower selling prices than the imported oil, making the value of energy exports obtained from coal, natural gas, and petroleum products smaller than the value of oil import, as shown on Chart 4.14. Thus, (2) energy term of trade indicates that Indonesia will be a net energy importer in 2015.

Chart 4.15 Baseline Forecasts of Energy Export and Import



Source: processed data

4.5. Simulation of Energy Demand and Oil Import in Indonesia

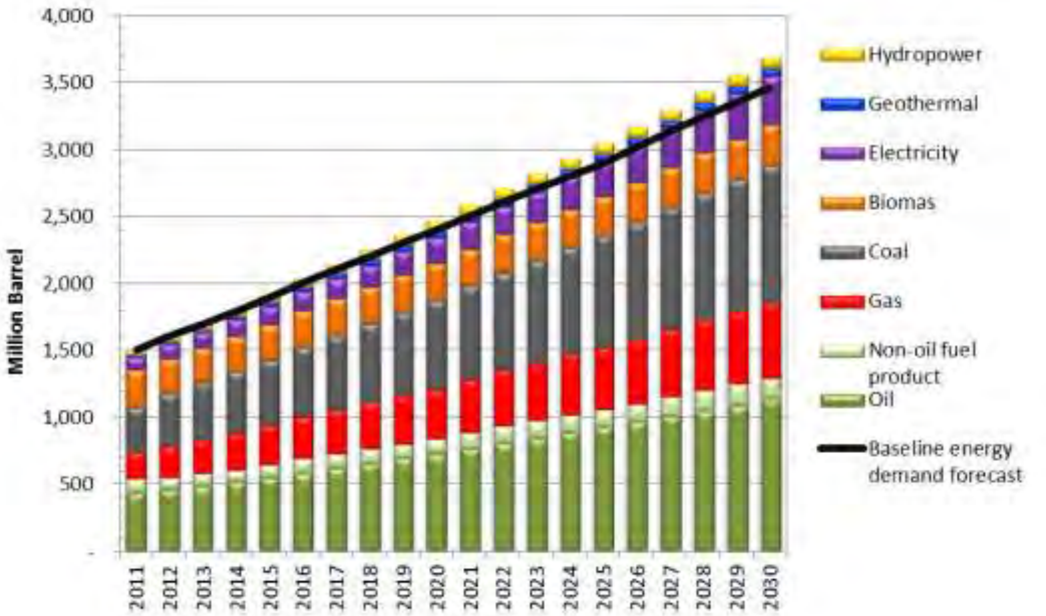
This subsection analyzes forecast simulation of energy demand and oil imports by the change of exogenous variables affecting oil import requirement.

4.5.1. Simulation of the Increasing GDP Growth Rate on Energy Demand and Oil Import

This simulation examines the effect of macroeconomic performance on energy consumption behavior and oil import, as presented in Table 4.11. Gross Domestic Product (GDP) is assumed to increase from the base scenario assumption of 5 percent per year to an average of 6 percent per year.

Higher growth rate of GDP of 1 percent leads to higher consumption of all energy types. Total energy consumption in 2030 is predicted to be 3,711 million BOE or increases by 7.2 percent from the baseline scenario, as shown in Chart 4.16. The growth of energy consumption rises to 4.9 percent per year, higher 0.4 percent from the baseline scenario.

Chart 4.16 Energy Demand Forecast in GDP Increase Scenario

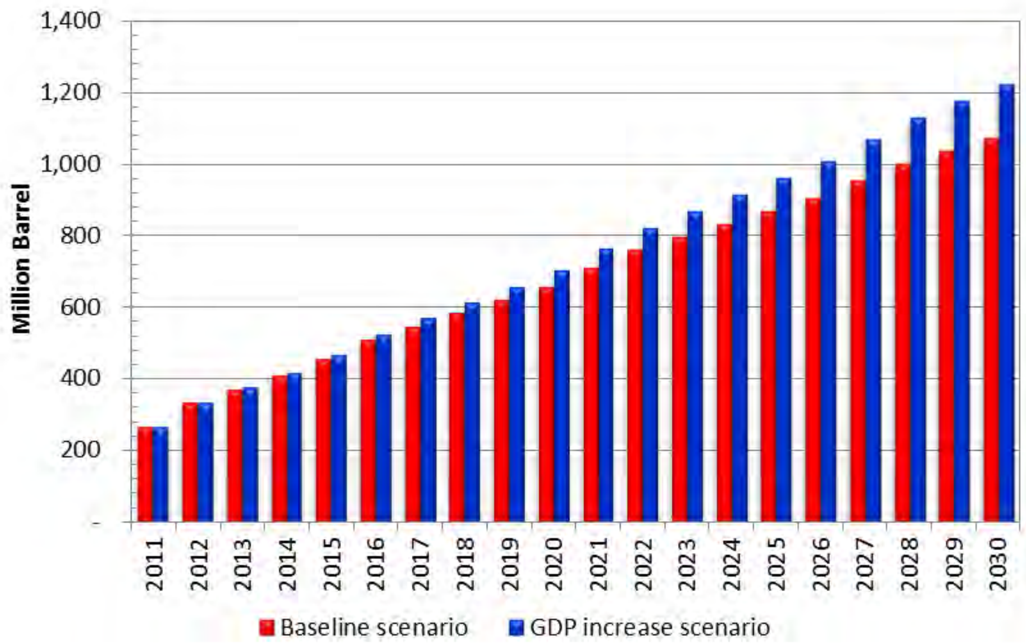


Source: processed data

The increase of GDP by 1 percent is predicted to increase oil fuel consumption by 0.8 percent per year or higher 15.7 percent than the baseline. It is similiar to other types of energy, such as natural gas, coal, and electricity which increase respectively by 5.2 percent, 3.6 percent, and 9.7 percent from the baseline.

Chart 4.17 shows that oil fuel consumption in 2030 is predicted to increase to 1,133 million BOE or equivalent to 3.1 million BOPD. This increases oil fuel import by 0.7 percent, from the growth of 7.7 percent per year in baseline scenario to 8.4 percent per year in 2030. Oil fuel import in 2030 is estimated at 1,226 million BOE (see Figure 4.19a) or equivalent to 3.3 million BOPD, comprising 492 million BOE of crude oil import (84 percent of the refinery capacities) and 734 million BOE of oil fuel import (65 percent of final oil fuel demand). The value of total oil import will grow to 1.460 trillion dollars in 2030, increasing by 14.3 percent.

Chart 4.17 Oil Import Forecast in GDP Increase Scenario



Source: processed data

Among the responses of the sectoral consumption, the effect on transport consumption (21.5 percent) is larger than commercial (4.5 percent) and residential sector (4 percent), in line with the increasing number of vehicles (Golshan *et al.*, 2013), as presented on Table 4.11. The increasing number of vehicles by 6.1 percent per year is induced by the increase in purchasing power and mobile activities to support economic growth. In 2030, oil fuel consumption in transportation sector is estimated to be 979 million BOE or equivalent to 156 million liters. Assuming the government subsidizes oil fuel demand (Hartanto *et al.,* 2012) on 80 percent of private car and buses, 20 percent of trucks, and 100 percent of motorcycle, then 585 million BOE or 93 million kiloliters of oil fuel should be subsidized and put on government budget plan in 2030.

Table 4.11 Energy Supply and Demand Forecast in GDP Increase Scenario

No	Variable name	Code	Unit	2011	2030	Annual growth (%)	Difference to baseline in 2030
1	Consumption of oil fuel at Electricity Generation sector	EGOLT	Thousand barrel	75,751	65,446	-0.70%	-10.6%
2	Consumption of oil fuel at Industrial sector	IDOLT	Thousand barrel	45,951	72,884	2.47%	0.0%
3	Consumption of oil fuel at Residential sector	REOLT	Thousand barrel	10,027	(5,896)	12.52%	-197.5%
4	Consumption of oil fuel at Transport sector	TROLT	Thousand barrel	277,170	979,582	6.88%	21.5%
5	Consumption of oil fuel at Commercial sector	COMOLT	Thousand barrel	5,817	1,431	-7.07%	0.0%
6	Consumption of oil fuel at Other sector	OCOLT	Thousand barrel	24,816	19,715	-1.20%	0.0%
7	Total of oil fuel consumption	FCOLT	Thousand barrel	439,532	1,133,161	5.11%	15.7%
8	Consumption of gas at Electricity Generation sector	EGGT	Thousand barrel	41,479	98,163	4.66%	16.1%
9	Consumption of gas at Industrial sector	IDGT	Thousand barrel	120,257	364,148	6.11%	0.9%
10	Consumption of gas at Residential sector	REGT	Thousand barrel	35,440	89,424	5.03%	9.5%
11	Consumption of gas at Transport sector	TRRTGT	Thousand barrel	181	250	1.75%	0.0%
12	Consumption of gas at Commercial sector	COMGT	Thousand barrel	2,402	15,739	10.46%	25.6%
13	Total of gas consumption	ECGT	Thousand barrel	199,759	567,725	5.72%	5.2%
14	Consumption of coal at Electricity Generation sector	EGCLT	Thousand barrel	189,498	543,222	5.71%	2.5%
15	Consumption of coal at Industrial sector	IDCLT	Thousand barrel	144,567	477,314	6.58%	4.9%
16	Consumption of coal at Residential sector	RECLT	Thousand barrel	108	240	4.28%	0.0%
17	Total of coal consumption	FCCLT	Thousand barrel	334,173	1,020,775	6.09%	3.6%
18	Consumption of electricity at Industrial sector	IDEGT	Thousand barrel	33,547	55,713	2.72%	6.9%
19	Consumption of electricity at Residential sector	REEGT	Thousand barrel	39,914	251,635	10.25%	12.8%
20	Consumption of electricity at Commercial sector	COMEGT	Thousand barrel	23,336	57,288	4.84%	0.0%
21	Total of electricity consumption	FCEGT	Thousand barrel	96,797	364,636	7.25%	9.7%
22	Consumption of biomass at Residential sector	REBIOT	Thousand barrel	280,171	303,901	0.45%	0.0%
23	Consumption of geothermal at Electricity Generation sector	EGGTT	Thousand barrel	16,494	60,000	7.39%	0.0%
24	Consumption of hydropower at Electricity Generation sector	EGHYT	Thousand barrel	31,269	86,503	5.69%	0.0%
25	Total of energy consumption	ECT	Thousand barrel	1,502,443	3,711,307	4.88%	7.2%
26	Refinery input	RFCRT	Thousand barrel	321,018	586,079	3.31%	0.0%
27	Refinerry output	OTPPT	Thousand barrel	341,384	553,550	2.69%	0.0%
28	Refinery production - oil fuel product	YBBMT	Thousand barrel	237,135	398,943	2.88%	0.0%
29	Refinery production - non-oil fuel product	YNBBMT	Thousand barrel	104,249	154,607	2.27%	0.0%
30	Import of crude oil	IMCRT	Thousand barrel	96,862	492,035	9.29%	0.0%
31	Import of oil fuel	IMPPT	Thousand barrel	172,113	734,218	8.14%	26.4%
32	Total of oil import	IMOLT	Thousand barrel	268,975	1,226,254	8.41%	14.3%
33	GDP at Electricity Generation sector	EGPT	Trillion Rupiah	11,959	56,534	8.52%	29.0%
34	GDP at Industrial sector	INDPT	Trillion Rupiah	634,247	1,124,502	3.06%	10.4%
35	GDP at Transport sector	TRPT	Trillion Rupiah	91,797	202,194	4.25%	20.5%
36	GDP at Commercial sector	COMPT	Trillion Rupiah	1,055,281	5,307,618	8.90%	27.4%
37	GDP at Other sector	OCPT	Trillion Rupiah	669,959	827,793	1.13%	12.1%
38	Total of GDP	PDBT	Trillion Rupiah	2,463,242	7,518,641	6.05%	22.6%
39	Total of oil import in value	IMV	Trillion Rupiah	263,077	1,459,902	10.00%	14.3%
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41	Total enegry consumption at industrial sector	IDECT	Thousand barrel	344,322	970,058	5.67%	3.1%
42	Total enegry consumption at electricity generation sector	EGECT	Thousand barrel	354,491	873,334	4.87%	2.2%
43	Total enegry consumption at commercial sector	COMECT	Thousand barrel	31,555	74,458	4.62%	4.5%
44	Total enegry consumption at transport sector	TRECT	Thousand barrel	277,351	979,832	6.88%	21.5%
45	Export of crude oil	EXOLT	Thousand barrel	135,572	31,348	-6.91%	0.0%
46	Export of natural gas	EXGT	Thousand barrel	240,622	140,275	-2.43%	-16.6%
47	Export of coal	EXCLT	Thousand barrel	1,145,220	2,158,326	3.49%	-1.6%
48	Number of vehicle	VEHI	Unit	85,601	314,396	7.11%	20.3%
49	Production of crude oil	IPOLT	Thousand barrel	335,041	131,898	-5.04%	0.0%
50	Production of natural gas	IPGT	Thousand barrel	542,730	720,000	1.52%	0.0%
51	Production of coal	IPCLT	Thousand barrel	1,483,738	2,948,560	4.13%	0.0%
52	Production of geothermal	IPGTT	Thousand barrel	16,494	59,115	7.39%	0.0%
53	Production of hydropower	IPHYTT	Thousand barrel	31,269	97,645	6.75%	0.0%

Source: processed data

In electricity generation sector, the increasing GDP will be used to convert diesel power plant to natural gas or coal power plant. It will reduce oil fuel demand by 10.6 percent in 2030 and increase natural gas and coal demand by 16.1 percent and 2.5 percent respectively, as presented on Table 4.11.

Economic growth allows certain improvement in living standards, including type of energy used. People will switch to modern and green energy, such as electricity and natural gas (Matheny, 2010). The use of kerosene in residential sector will be replaced by LPG and electricity. Demands for both energy types will increase by 9.5 percent and 12.8 percent in 2030 compared to the baseline scenario.

4.5.2. Simulation of the Increasing Oil Price Subsidy on Energy Demand and Oil Import

This simulation examines the effect of macroeconomic performance through subsidy budget reduction on energy consumption behavior and oil import, as presented on Table 4.12. Reduction of subsidy budget will increase the price of subsidized oil fuel. The price of the subsidized oil fuel assumed at Rp. 4.500/liter will increase to Rp. 6.500/liter in 2013 and rise every four years towards international oil price.

Simulation result in Table 4.12 shows that the increasing price of subsidized oil fuel would directly reduce oil fuel demand in all economic sectors and government expenditures. When the subsidized oil fuel price started to rise in 2013, oil fuel consumption in all economic sectors decreased by 5 percent compared to the baseline scenario. In 2030, oil fuel consumption falls by 6 percent from the baseline scenario to 920 million BOE.

Table 4.12 Energy Supply and Demand Forecast in the Increasing Price of Subsidized Oil Fuel Scenario

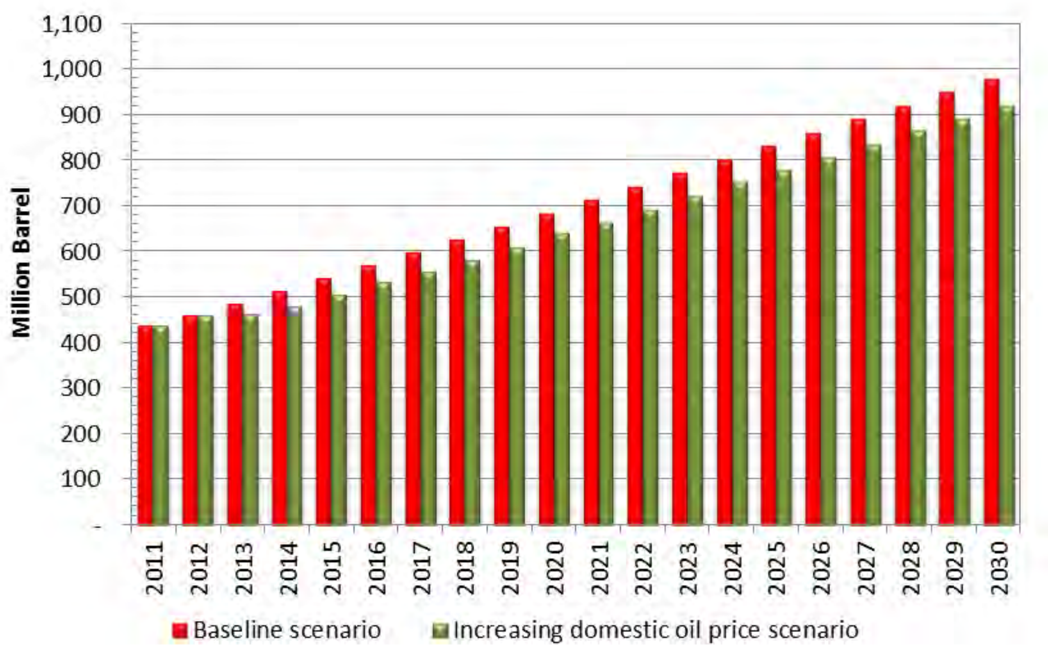
No	Variable name	Code	Unit	2011	2030	Annual growth (%)	Difference to baseline in 2030
1	Consumption of oil fuel at Electricity Generation sector	EGOLT	Thousand barrel	75,751	86,277	0.86%	17.9%
2	Consumption of oil fuel at Industrial sector	IDOLT	Thousand barrel	45,951	59,877	1.52%	-17.8%
3	Consumption of oil fuel at Residential sector	REOLT	Thousand barrel	10,027	6,049	-2.54%	0.0%
4	Consumption of oil fuel at Transport sector	TROLT	Thousand barrel	277,170	755,045	5.44%	-6.4%
5	Consumption of oil fuel at Commercial sector	COMOLT	Thousand barrel	5,817	(3,171)	12.69%	-321.7%
6	Consumption of oil fuel at Other sector	OCOLT	Thousand barrel	24,816	16,427	-2.14%	-16.7%
7	Total of oil fuel consumption	FCOLT	Thousand barrel	439,532	920,504	3.97%	-6.0%
8	Consumption of gas at Electricity Generation sector	EGGT	Thousand barrel	41,479	84,555	3.84%	0.0%
9	Consumption of gas at Industrial sector	IDGT	Thousand barrel	120,257	360,820	6.06%	0.0%
10	Consumption of gas at Residential sector	REGT	Thousand barrel	35,440	81,677	4.53%	0.0%
11	Consumption of gas at Transport sector	TRRTGT	Thousand barrel	181	250	1.75%	0.0%
12	Consumption of gas at Commercial sector	COMGT	Thousand barrel	2,402	12,531	9.15%	0.0%
13	Total of gas consumption	ECGT	Thousand barrel	199,759	539,834	5.44%	0.0%
14	Consumption of coal at Electricity Generation sector	EGCLT	Thousand barrel	189,498	544,379	5.73%	2.7%
15	Consumption of coal at Industrial sector	IDCLT	Thousand barrel	144,567	466,636	6.45%	2.6%
16	Consumption of coal at Residential sector	RECLT	Thousand barrel	108	240	4.28%	0.0%
17	Total of coal consumption	FCCLT	Thousand barrel	334,173	1,011,255	6.04%	2.6%
18	Consumption of electricity at Industrial sector	IDEGT	Thousand barrel	33,547	52,116	2.36%	0.0%
19	Consumption of electricity at Residential sector	REEGT	Thousand barrel	39,914	223,034	9.56%	0.0%
20	Consumption of electricity at Commercial sector	COMEGT	Thousand barrel	23,336	57,288	4.84%	0.0%
21	Total of electricity consumption	FCEGT	Thousand barrel	96,797	332,438	6.73%	0.0%
22	Consumption of biomass at Residential sector	REBIOT	Thousand barrel	280,171	303,901	0.45%	0.0%
23	Consumption of geothermal at Electricity Generation sector	EGGTT	Thousand barrel	16,494	60,000	7.39%	0.0%
24	Consumption of hydropower at Electricity Generation sector	EGHYT	Thousand barrel	31,269	86,503	5.69%	0.0%
25	Total of energy consumption	ECT	Thousand barrel	1,502,443	3,429,041	4.44%	-1.0%
26	Refinery input	RFCRT	Thousand barrel	321,018	586,079	3.31%	0.0%
27	Refinerry output	OTPPT	Thousand barrel	341,384	553,550	2.69%	0.0%
28	Refinery production - oil fuel product	YBBMT	Thousand barrel	237,135	398,943	2.88%	0.0%
29	Refinery production - non-oil fuel product	YNBBMT	Thousand barrel	104,249	154,607	2.27%	0.0%
30	Import of crude oil	IMCRT	Thousand barrel	96,862	492,035	9.29%	0.0%
31	Import of oil fuel	IMPPT	Thousand barrel	172,113	521,561	6.25%	-10.2%
32	Total of oil import	IMOLT	Thousand barrel	268,975	1,013,596	7.33%	-5.5%
33	GDP at Electricity Generation sector	EGPT	Trillion Rupiah	11,959	43,833	7.08%	0.0%
34	GDP at Industrial sector	INDPT	Trillion Rupiah	634,247	1,018,624	2.53%	0.0%
35	GDP at Transport sector	TRPT	Trillion Rupiah	91,797	167,730	3.23%	0.0%
36	GDP at Commercial sector	COMPT	Trillion Rupiah	1,055,281	4,164,849	7.52%	0.0%
37	GDP at Other sector	OCPT	Trillion Rupiah	669,959	738,374	0.52%	0.0%
38	Total of GDP	PDBT	Trillion Rupiah	2,463,242	6,133,411	4.92%	0.0%
39	Total of oil import in value	IMV	Trillion Rupiah	263,077	1,206,725	9.05%	-5.5%
40	Total enegry consumption at residential sector	REECT	Thousand barrel	365,660	614,901	2.78%	0.0%
41	Total enegry consumption at industrial sector	IDECT	Thousand barrel	344,322	939,449	5.49%	-0.1%
42	Total enegry consumption at electricity generation sector	EGECT	Thousand barrel	354,491	881,714	4.94%	3.2%
43	Total enegry consumption at commercial sector	COMECT	Thousand barrel	31,555	66,647	4.02%	-6.5%
44	Total enegry consumption at transport sector	TRECT	Thousand barrel	277,351	755,295	5.44%	-6.4%
45	Export of crude oil	EXOLT	Thousand barrel	135,572	31,348	-6.91%	0.0%
46	Export of natural gas	EXGT	Thousand barrel	240,622	168,166	-1.55%	0.0%
47	Export of coal	EXCLT	Thousand barrel	1,145,220	2,167,846	3.52%	-1.2%
48	Number of vehicle	VEHI	Unit	85,601	261,296	6.07%	0.0%
49	Production of crude oil	IPOLT	Thousand barrel	335,041	131,898	-5.04%	0.0%
50	Production of natural gas	IPGT	Thousand barrel	542,730	720,000	1.52%	0.0%
51	Production of coal	IPCLT	Thousand barrel	1,483,738	2,948,560	4.13%	0.0%
52	Production of geothermal	IPGTT	Thousand barrel	16,494	59,115	7.39%	0.0%
53	Production of hydropower	IPHYTT	Thousand barrel	31,269	97,645	6.75%	0.0%

Source: processed data

Industrial sector responds by shifting to non-oil fuel energy, such as coal. In 2030, oil fuel consumption falls by 17.8 percent while coal consumption increases by 2.6 percent from the baseline scenario. However, oil fuel consumption in this sector remains high as its role as a feedstock cannot be replaced by other energy.

The increasing price of the subsidized oil fuel has relatively small effect on oil consumption in transportation sector, i.e. 5 percent from baseline scenario in 2013 and 6 percent in 2030. It is reported that Indonesians spend 2.6 percent of their income on oil fuel, so the rising price of the subsidized oil fuel still does not interfere their demand (bloomberg.com).

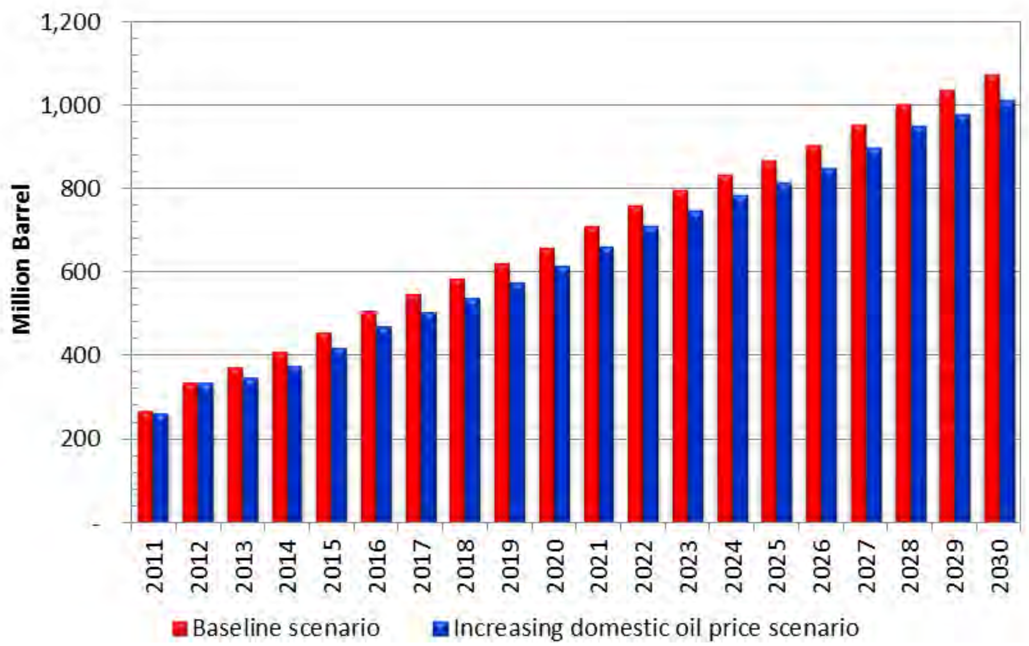
Chart 4.18 Oil Fuel Consumption Forecast in Baseline and Increasing Subsidy Price Scenarios



Source: processed data

Chart 4.18 and 4.19 present the effect of the increasing price of the subsidized oil fuel on its consumption and import. The value of oil import falls by 5.5 percent from the baseline scenario in 2030 to Rp 1,206 trillion. In 2013, the amount of oil fuel import is estimated at 231 million BOE or 634 thousand BOPD, decreasing by 10 percent from the baseline forecast.

Chart 4.19 Oil Fuel Import Forecast in Baseline and Increasing Subsidy Price Scenarios



Source: processed data

The decreasing oil fuel consumption as the effect of the increasing oil price will increase the consumption of other types of energy, such as natural gas and coal, particularly in electricity generation, industrial, and commercial sectors. The total energy consumption in 2030 is 3,429 million BOE, falling by 1 percent from the baseline scenario.

4.5.3. Simulation of the Increasing International Oil Price on Energy Demand and Oil Import

This simulation examines the effect of global economic changes in the increasing international oil price on energy consumption behavior and oil import, as presented on Table 4.13. International oil price is assumed increasing from 1.04 percent per year at the baseline scenario to 2.04 percent per year.

Statistical test result and analysis in section 4.2.c confirm that the increasing international oil price does not have significant effect on the consumption of oil fuel due to government distortion on domestic oil fuel price through subsidy policy. Meanwhile, energy forecast on Table 4.13 presents that to fulfill 54 percent of domestic oil fuel demand, domestic oil refineries have to import crude oil by 84 percent. This high dependency on crude oil import suggests that demand for crude oil is not sensitive to international oil price.

The increase of international oil price by 1 percent will enlarge the gap between the subsidized and non-subsidized oil fuel price that will increase government's cost of subsidy, reduce government's saving and investment budget while oil fuel demand keeps on increasing. It will burden the balance of payment due to high oil import, increase inflation, and decrease national income (Surjadi, 2006).

In term of value, oil import will grow by 9.85 percent per year to Rp. 1,540 trillion in 2030, increasing 20.6 percent compared with the baseline forecast, as shown on Chart 4.20.

Table 4.13 Energy Supply and Demand Forecast in Increasing International Oil Price Scenario

No	Variable name	Code	Unit	2011	2030	Annual growth (%)	Difference to baseline in 2030
1	Consumption of oil fuel at Electricity Generation sector	EGOLT	Thousand barrel	75,751	73,193	-0.11%	0.0%
2	Consumption of oil fuel at Industrial sector	IDOLT	Thousand barrel	45,951	72,884	2.47%	0.0%
3	Consumption of oil fuel at Residential sector	REOLT	Thousand barrel	10,027	6,049	-2.54%	0.0%
4	Consumption of oil fuel at Transport sector	TROLT	Thousand barrel	277,170	806,318	5.80%	0.0%
5	Consumption of oil fuel at Commercial sector	COMOLT	Thousand barrel	5,817	1,431	-7.07%	0.0%
6	Consumption of oil fuel at Other sector	OCOLT	Thousand barrel	24,816	19,715	-1.20%	0.0%
7	Total of oil fuel consumption	FCOLT	Thousand barrel	439,532	979,589	4.31%	0.0%
8	Consumption of gas at Electricity Generation sector	EGGT	Thousand barrel	41,479	84,555	3.84%	0.0%
9	Consumption of gas at Industrial sector	IDGT	Thousand barrel	120,257	360,820	6.06%	0.0%
10	Consumption of gas at Residential sector	REGT	Thousand barrel	35,440	81,677	4.53%	0.0%
11	Consumption of gas at Transport sector	TRRTGT	Thousand barrel	181	250	1.75%	0.0%
12	Consumption of gas at Commercial sector	COMGT	Thousand barrel	2,402	12,531	9.15%	0.0%
13	Total of gas consumption	ECGT	Thousand barrel	199,759	539,834	5.44%	0.0%
14	Consumption of coal at Electricity Generation sector	EGCLT	Thousand barrel	189,498	529,991	5.57%	0.0%
15	Consumption of coal at Industrial sector	IDCLT	Thousand barrel	144,567	454,940	6.30%	0.0%
16	Consumption of coal at Residential sector	RECLT	Thousand barrel	108	240	4.28%	0.0%
17	Total of coal consumption	FCCLT	Thousand barrel	334,173	985,171	5.88%	0.0%
18	Consumption of electricity at Industrial sector	IDEGT	Thousand barrel	33,547	52,116	2.36%	0.0%
19	Consumption of electricity at Residential sector	REEGT	Thousand barrel	39,914	223,034	9.56%	0.0%
20	Consumption of electricity at Commercial sector	COMEGT	Thousand barrel	23,336	57,288	4.84%	0.0%
21	Total of electricity consumption	FCEGT	Thousand barrel	96,797	332,438	6.73%	0.0%
22	Consumption of biomass at Residential sector	REBIOT	Thousand barrel	280,171	303,901	0.45%	0.0%
23	Consumption of geothermal at Electricity Generation sector	EGGTT	Thousand barrel	16,494	60,000	7.39%	0.0%
24	Consumption of hydropower at Electricity Generation sector	EGHYT	Thousand barrel	31,269	86,503	5.69%	0.0%
25	Total of energy consumption	ECT	Thousand barrel	1,502,443	3,462,042	4.50%	0.0%
26	Refinery input	RFCRT	Thousand barrel	321,018	586,079	3.31%	0.0%
27	Refinerry output	OTPPT	Thousand barrel	341,384	553,550	2.69%	0.0%
28	Refinery production - oil fuel product	YBBMT	Thousand barrel	237,135	398,943	2.88%	0.0%
29	Refinery production - non-oil fuel product	YNBBMT	Thousand barrel	104,249	154,607	2.27%	0.0%
30	Import of crude oil	IMCRT	Thousand barrel	96,862	492,035	9.29%	0.0%
31	Import of oil fuel	IMPPT	Thousand barrel	172,113	580,646	6.84%	0.0%
32	Total of oil import	IMOLT	Thousand barrel	268,975	1,072,681	7.65%	0.0%
33	GDP at Electricity Generation sector	EGPT	Trillion Rupiah	11,959	43,833	7.08%	0.0%
34	GDP at Industrial sector	INDPT	Trillion Rupiah	634,247	1,018,624	2.53%	0.0%
35	GDP at Transport sector	TRPT	Trillion Rupiah	91,797	167,730	3.23%	0.0%
36	GDP at Commercial sector	COMPT	Trillion Rupiah	1,055,281	4,164,849	7.52%	0.0%
37	GDP at Other sector	OCPT	Trillion Rupiah	669,959	738,374	0.52%	0.0%
38	Total of GDP	PDBT	Trillion Rupiah	2,463,242	6,133,411	4.92%	0.0%
39	Total of oil import in value	IMV	Trillion Rupiah	263,077	1,539,852	9.85%	20.6%
40	Total enegry consumption at residential sector	REECT	Thousand barrel	365,660	614,901	2.78%	0.0%
41	Total enegry consumption at industrial sector	IDECT	Thousand barrel	344,322	940,761	5.49%	0.0%
42	Total enegry consumption at electricity generation sector	EGECT	Thousand barrel	354,491	854,241	4.75%	0.0%
43	Total enegry consumption at commercial sector	COMECT	Thousand barrel	31,555	71,250	4.38%	0.0%
44	Total enegry consumption at transport sector	TRECT	Thousand barrel	277,351	806,568	5.79%	0.0%
45	Export of crude oil	EXOLT	Thousand barrel	135,572	31,348	-6.91%	0.0%
46	Export of natural gas	EXGT	Thousand barrel	240,622	168,166	-1.55%	0.0%
47	Export of coal	EXCLT	Thousand barrel	1,145,220	2,193,930	3.58%	0.0%
48	Number of vehicle	VEHI	Unit	85,601	261,296	6.07%	0.0%
49	Production of crude oil	IPOLT	Thousand barrel	335,041	131,898	-5.04%	0.0%
50	Production of natural gas	IPGT	Thousand barrel	542,730	720,000	1.52%	0.0%
51	Production of coal	IPCLT	Thousand barrel	1,483,738	2,948,560	4.13%	0.0%
52	Production of geothermal	IPGTT	Thousand barrel	16,494	59,115	7.39%	0.0%
53	Production of hydropower	IPHYTT	Thousand barrel	31,269	97,645	6.75%	0.0%

Source: processed data

Chart 4.20 Value of Oil Fuel Import Forecast in Baseline and Increasing International Oil Price Scenarios

Source: processed data

4.5.4. Simulation of the Increasing Crude Oil Production on Energy Demand and Oil Import

The simulation examines the effect of energy policy implementation on energy consumption behavior and oil import. According to Presidential Decree No.2/2012, crude oil production is planned to increase in 2014 by intensification of exploration activities, Cepu Block's put on production, mature field optimization, and coordination between government agencies in non-technical issues, such as land acquisition and overlapping. Crude oil production is assumed to increase by 1 million barrel oil per day followed by the production decline in the following year.

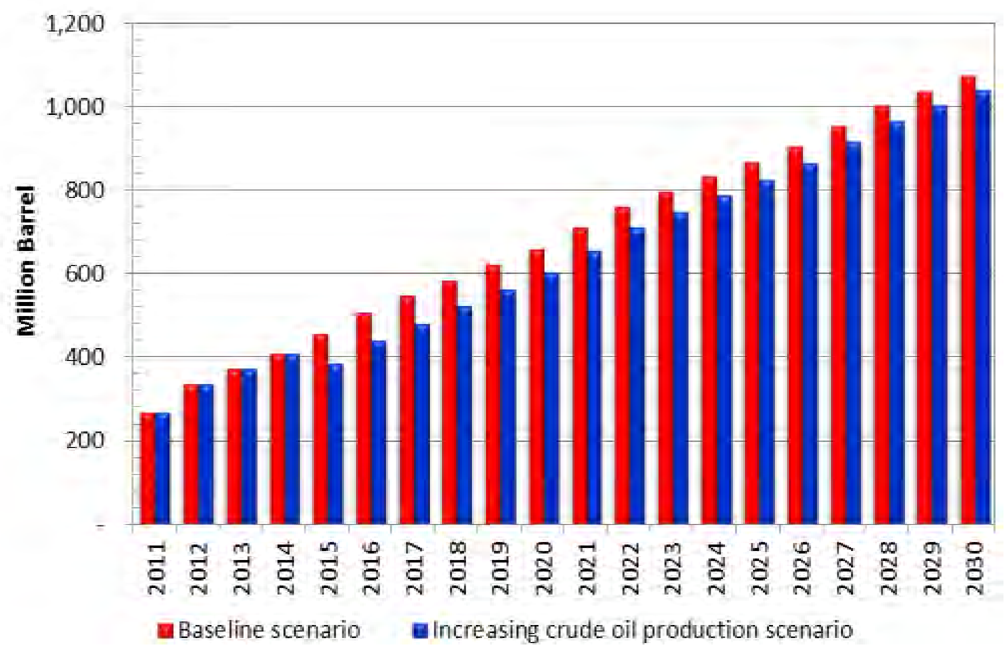
Table 4.14 Energy Supply and Demand Forecast in Increasing Crude Oil Production Scenario

No	Variable name	Code	Unit	2011	2030	Annual growth (%)	Difference to baseline in 2030
1	Consumption of oil fuel at Electricity Generation sector	EGOLT	Thousand barrel	75,751	73,193	-0.11%	0.0%
2	Consumption of oil fuel at Industrial sector	IDOLT	Thousand barrel	45,951	72,884	2.47%	0.0%
3	Consumption of oil fuel at Residential sector	REOLT	Thousand barrel	10,027	6,049	-2.54%	0.0%
4	Consumption of oil fuel at Transport sector	TROLT	Thousand barrel	277,170	806,318	5.80%	0.0%
5	Consumption of oil fuel at Commercial sector	COMOLT	Thousand barrel	5,817	1,431	-7.07%	0.0%
6	Consumption of oil fuel at Other sector	OCOLT	Thousand barrel	24,816	19,715	-1.20%	0.0%
7	Total of oil fuel consumption	FCOLT	Thousand barrel	439,532	979,589	4.31%	0.0%
8	Consumption of gas at Electricity Generation sector	EGGT	Thousand barrel	41,479	84,555	3.84%	0.0%
9	Consumption of gas at Industrial sector	IDGT	Thousand barrel	120,257	360,820	6.06%	0.0%
10	Consumption of gas at Residential sector	REGT	Thousand barrel	35,440	81,677	4.53%	0.0%
11	Consumption of gas at Transport sector	TRRTGT	Thousand barrel	181	250	1.75%	0.0%
12	Consumption of gas at Commercial sector	COMGT	Thousand barrel	2,402	12,531	9.15%	0.0%
13	Total of gas consumption	ECGT	Thousand barrel	199,759	539,834	5.44%	0.0%
14	Consumption of coal at Electricity Generation sector	EGCLT	Thousand barrel	189,498	529,991	5.57%	0.0%
15	Consumption of coal at Industrial sector	IDCLT	Thousand barrel	144,567	454,940	6.30%	0.0%
16	Consumption of coal at Residential sector	RECLT	Thousand barrel	108	240	4.28%	0.0%
17	Total of coal consumption	FCCLT	Thousand barrel	334,173	985,171	5.88%	0.0%
18	Consumption of electricity at Industrial sector	IDEGT	Thousand barrel	33,547	52,116	2.36%	0.0%
19	Consumption of electricity at Residential sector	REEGT	Thousand barrel	39,914	223,034	9.56%	0.0%
20	Consumption of electricity at Commercial sector	COMEGT	Thousand barrel	23,336	57,288	4.84%	0.0%
21	Total of electricity consumption	FCEGT	Thousand barrel	96,797	332,438	6.73%	0.0%
22	Consumption of biomass at Residential sector	REBIOT	Thousand barrel	280,171	303,901	0.45%	0.0%
23	Consumption of geothermal at Electricity Generation sector	EGGTT	Thousand barrel	16,494	60,000	7.39%	0.0%
24	Consumption of hydropower at Electricity Generation sector	EGHYT	Thousand barrel	31,269	86,503	5.69%	0.0%
25	Total of energy consumption	ECT	Thousand barrel	1,502,443	3,462,042	4.50%	0.0%
26	Refinery input	RFCRT	Thousand barrel	321,018	586,079	3.31%	0.0%
27	Refinerry output	OTPPT	Thousand barrel	341,384	553,550	2.69%	0.0%
28	Refinery production - oil fuel product	YBBMT	Thousand barrel	237,135	398,943	2.88%	0.0%
29	Refinery production - non-oil fuel product	YNBBMT	Thousand barrel	104,249	154,607	2.27%	0.0%
30	Import of crude oil	IMCRT	Thousand barrel	96,862	459,253	9.74%	-6.7%
31	Import of oil fuel	IMPPT	Thousand barrel	172,113	580,646	6.84%	0.0%
32	Total of oil import	IMOLT	Thousand barrel	268,975	1,039,899	7.53%	-3.1%
33	GDP at Electricity Generation sector	EGPT	Trillion Rupiah	11,959	43,833	7.08%	0.0%
34	GDP at Industrial sector	INDPT	Trillion Rupiah	634,247	1,018,624	2.53%	0.0%
35	GDP at Transport sector	TRPT	Trillion Rupiah	91,797	167,730	3.23%	0.0%
36	GDP at Commercial sector	COMPT	Trillion Rupiah	1,055,281	4,164,849	7.52%	0.0%
37	GDP at Other sector	OCPT	Trillion Rupiah	669,959	738,374	0.52%	0.0%
38	Total of GDP	PDBT	Trillion Rupiah	2,463,242	6,133,411	4.92%	0.0%
39	Total of oil import in value	IMV	Trillion Rupiah	263,077	1,238,039	9.17%	-3.1%
40	Total enegry consumption at residential sector	REECT	Thousand barrel	365,660	614,901	2.78%	0.0%
41	Total enegry consumption at industrial sector	IDECT	Thousand barrel	344,322	940,761	5.49%	0.0%
42	Total enegry consumption at electricity generation sector	EGECT	Thousand barrel	354,491	854,241	4.75%	0.0%
43	Total enegry consumption at commercial sector	COMECT	Thousand barrel	31,555	71,250	4.38%	0.0%
44	Total enegry consumption at transport sector	TRECT	Thousand barrel	277,351	806,568	5.79%	0.0%
45	Export of crude oil	EXOLT	Thousand barrel	135,572	42,275	-5.15%	34.9%
46	Export of natural gas	EXGT	Thousand barrel	240,622	168,166	-1.55%	0.0%
47	Export of coal	EXCLT	Thousand barrel	1,145,220	2,193,930	3.58%	0.0%
48	Number of vehicle	VEHI	Unit	85,601	261,296	6.07%	0.0%
49	Production of crude oil	IPOLT	Thousand barrel	335,041	**169,101**	-3.28%	28.2%
50	Production of natural gas	IPGT	Thousand barrel	542,730	720,000	1.52%	0.0%
51	Production of coal	IPCLT	Thousand barrel	1,483,738	2,948,560	4.13%	0.0%
52	Production of geothermal	IPGTT	Thousand barrel	16,494	59,115	7.39%	0.0%
53	Production of hydropower	IPHYTT	Thousand barrel	31,269	97,645	6.75%	0.0%

Source: processed data

The simulation in Table 4.14 predicts that crude oil production is estimated to increase from the level of 132 million BOE at the baseline scenario to 169 million BOE (463 thousand BOPD) in 2030, declining by 3.28 percent per year. With the refinery capacities of 586 million BOE (1.6 million BOPD) to cover the projected oil fuel demand of 979 million BOE (2.7 million BOPD) in 2030, the large crude oil production will only directly reduce crude oil import by 6.7 percent in 2030, decreasing from the level of 492 million BOE in the baseline scenario to 459 million BOE. However, the increasing crude oil production will not affect oil fuel import because the transformation capacity to produce oil fuel remains lower than its demand. Thus, the total value of oil import, both in crude oil and oil fuel in 2030 are expected to decrease by 3.1 percent from the baseline scenario.

Chart 4.21 Oil Fuel Import Forecast in Baseline and Increasing Crude Oil Production Scenarios



Source: processed data

4.5.5. Simulation of the Increasing Refinery Efficiency on Energy Demand and Oil Import

Until 2011, Indonesia only had 10 oil refineries with a total capacity of 1,157 thousand BOPD, but they only consumed 933 thousand BOPD of crude oil as an input. It shows only 81 percent rate of refinery efficiency. This simulation examines the effect of refinery efficiency improvement to maximize existing capabilities on energy consumption behavior and oil import. Refinery efficiency is assumed to increase gradually to 95 percent in 2030.

The simulation result in Table 4.15 suggests that more efficient refinery technology increases refinery output. This simulation shows the increase in refinery output by 18.4 percent from 586 million BOE to 655 million BOE. It will result in the decreasing oil fuel import by 12.7 percent in 2030 and reduce oil import dependency.

The simulation also suggests that the more efficient refinery technology will increase refinery input. As a result, crude oil import is estimated to increase by 18 percent in 2030 compared to the baseline scenario, thus increases total oil import by 3.2 percent.

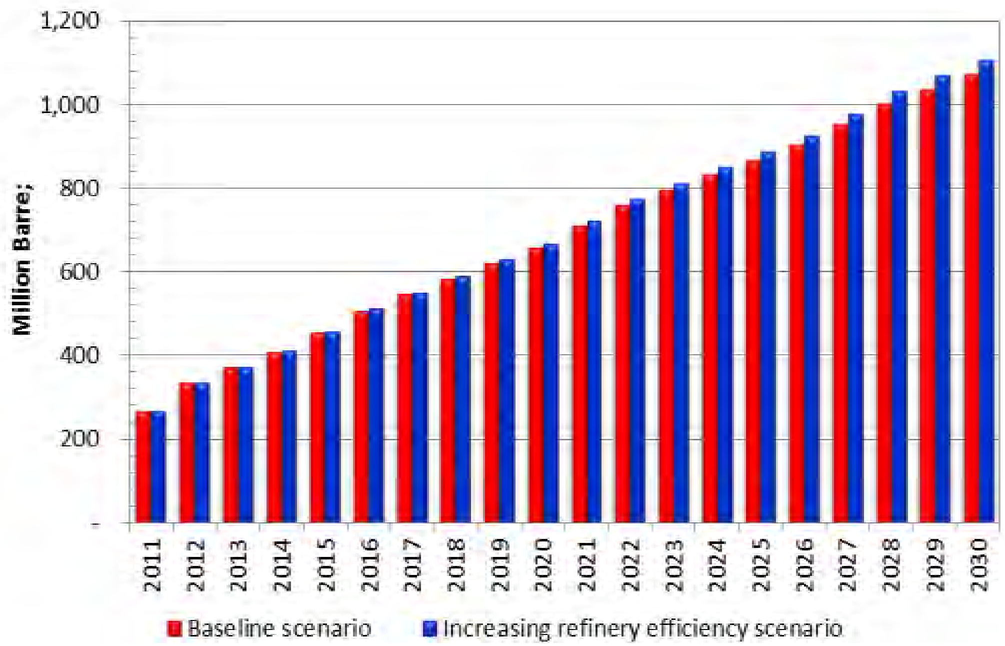
Table 4.15 shows that the increasing crude oil import in the amount of 108 million BOE cannot be covered by the decreasing oil fuel import of 73 million BOE. That will increase the total oil import value by 3.2 percent from the baseline scenario, or increase to Rp 1,318 trillion in 2030. Chart 4.22 presents the estimation of oil import in both scenarios.

Table 4.15 Energy Supply and Demand Forecast in Increasing Refinery Efficiency Scenario

No	Variable name	Code	Unit	2011	2030	Annual growth (%)	Difference to baseline in 2030
1	Consumption of oil fuel at Electricity Generation sector	EGOLT	Thousand barrel	75,751	73,193	-0.11%	0.0%
2	Consumption of oil fuel at Industrial sector	IDOLT	Thousand barrel	45,951	72,884	2.47%	0.0%
3	Consumption of oil fuel at Residential sector	REOLT	Thousand barrel	10,027	6,049	-2.54%	0.0%
4	Consumption of oil fuel at Transport sector	TROLT	Thousand barrel	277,170	806,318	5.80%	0.0%
5	Consumption of oil fuel at Commercial sector	COMOLT	Thousand barrel	5,817	1,431	-7.07%	0.0%
6	Consumption of oil fuel at Other sector	OCOLT	Thousand barrel	24,816	19,715	-1.20%	0.0%
7	Total of oil fuel consumption	FCOLT	Thousand barrel	439,532	979,589	4.31%	0.0%
8	Consumption of gas at Electricity Generation sector	EGGT	Thousand barrel	41,479	84,555	3.84%	0.0%
9	Consumption of gas at Industrial sector	IDGT	Thousand barrel	120,257	360,820	6.06%	0.0%
10	Consumption of gas at Residential sector	REGT	Thousand barrel	35,440	81,677	4.53%	0.0%
11	Consumption of gas at Transport sector	TRRTGT	Thousand barrel	181	250	1.75%	0.0%
12	Consumption of gas at Commercial sector	COMGT	Thousand barrel	2,402	12,531	9.15%	0.0%
13	Total of gas consumption	ECGT	Thousand barrel	199,759	539,834	5.44%	0.0%
14	Consumption of coal at Electricity Generation sector	EGCLT	Thousand barrel	189,498	529,991	5.57%	0.0%
15	Consumption of coal at Industrial sector	IDCLT	Thousand barrel	144,567	454,940	6.30%	0.0%
16	Consumption of coal at Residential sector	RECLT	Thousand barrel	108	240	4.28%	0.0%
17	Total of coal consumption	FCCLT	Thousand barrel	334,173	985,171	5.88%	0.0%
18	Consumption of electricity at Industrial sector	IDEGT	Thousand barrel	33,547	52,116	2.36%	0.0%
19	Consumption of electricity at Residential sector	REEGT	Thousand barrel	39,914	223,034	9.56%	0.0%
20	Consumption of electricity at Commercial sector	COMEGT	Thousand barrel	23,336	57,288	4.84%	0.0%
21	Total of electricity consumption	FCEGT	Thousand barrel	96,797	332,438	6.73%	0.0%
22	Consumption of biomass at Residential sector	REBIOT	Thousand barrel	280,171	303,901	0.45%	0.0%
23	Consumption of geothermal at Electricity Generation sector	EGGTT	Thousand barrel	16,494	60,000	7.39%	0.0%
24	Consumption of hydropower at Electricity Generation sector	EGHYT	Thousand barrel	31,269	86,503	5.69%	0.0%
25	Total of energy consumption	ECT	Thousand barrel	1,502,443	3,490,537	4.54%	0.8%
26	Refinery input	RFCRT	Thousand barrel	321,018	694,096	4.24%	18.4%
27	Refinerry output	OTPPT	Thousand barrel	341,384	655,572	3.61%	18.4%
28	Refinery production - oil fuel product	YBBMT	Thousand barrel	237,135	472,470	3.80%	18.4%
29	Refinery production - non-oil fuel product	YNBBMT	Thousand barrel	104,249	183,102	3.19%	18.4%
30	Import of crude oil	IMCRT	Thousand barrel	96,862	600,052	10.43%	22.0%
31	Import of oil fuel	IMPPT	Thousand barrel	172,113	507,119	6.11%	-12.7%
32	Total of oil import	IMOLT	Thousand barrel	268,975	1,107,171	7.83%	3.2%
33	GDP at Electricity Generation sector	EGPT	Trillion Rupiah	11,959	43,833	7.08%	0.0%
34	GDP at Industrial sector	INDPT	Trillion Rupiah	634,247	1,018,624	2.53%	0.0%
35	GDP at Transport sector	TRPT	Trillion Rupiah	91,797	167,730	3.23%	0.0%
36	GDP at Commercial sector	COMPT	Trillion Rupiah	1,055,281	4,164,849	7.52%	0.0%
37	GDP at Other sector	OCPT	Trillion Rupiah	669,959	738,374	0.52%	0.0%
38	Total of GDP	PDBT	Trillion Rupiah	2,463,242	6,133,411	4.92%	0.0%
39	Total of oil import in value	IMV	Trillion Rupiah	263,077	1,318,129	9.55%	3.2%
40	Total enegry consumption at residential sector	REECT	Thousand barrel	365,660	614,901	2.78%	0.0%
41	Total enegry consumption at industrial sector	IDECT	Thousand barrel	344,322	940,761	5.49%	0.0%
42	Total enegry consumption at electricity generation sector	EGECT	Thousand barrel	354,491	854,241	4.75%	0.0%
43	Total enegry consumption at commercial sector	COMECT	Thousand barrel	31,555	71,250	4.38%	0.0%
44	Total enegry consumption at transport sector	TRECT	Thousand barrel	277,351	806,568	5.79%	0.0%
45	Export of crude oil	EXOLT	Thousand barrel	135,572	31,348	-6.91%	0.0%
46	Export of natural gas	EXGT	Thousand barrel	240,622	168,166	-1.55%	0.0%
47	Export of coal	EXCLT	Thousand barrel	1,145,220	2,193,930	3.58%	0.0%
48	Number of vehicle	VEHI	Unit	85,601	261,296	6.07%	0.0%
49	Production of crude oil	IPOLT	Thousand barrel	335,041	131,898	-5.04%	0.0%
50	Production of natural gas	IPGT	Thousand barrel	542,730	720,000	1.52%	0.0%
51	Production of coal	IPCLT	Thousand barrel	1,483,738	2,948,560	4.13%	0.0%
52	Production of geothermal	IPGTT	Thousand barrel	16,494	59,115	7.39%	0.0%
53	Production of hydropower	IPHYTT	Thousand barrel	31,269	97,645	6.75%	0.0%

Source: processed data

Chart 4.22 Oil Import Forecast in Baseline and Increasing Refinery Efficiency Scenarios



Source: processed data

4.5.6. Simulation of Energy Diversification on Energy Demand and Oil Import

Energy diversification is a strategy deployed to bolster both economic and physical security, thereby mitigating the risk of manipulation from foreign entities that may have a monopoly on specific non-renewable energy sources, such as oil. Diversification program includes conversion of oil based energy into non-oil energy source, such as gas and coal.

In Indonesia, kerosene and LPG conversion program which has been successfully implemented by government and local communities since 2007 and has reduced oil fuel demand by 83 percent (MoEMR, 2013) still needs to be continually improved. Subsidy cuts have forced residential, commercial, and industrial consumers to reduce their oil fuel consumption to shift to non-oil energy source. Energy shifting in industrial and electricity generation sector is not easy to conduct because it requires technology changes and conversion tools for the equipments and machineries. Besides, oil fuel demand in industrial sector cannot be entirely replaced by other type of energy due to its function as a feedstock.

In transportation sector, government had made a roadmap to reduce oil fuel dependency by converting oil fuel to CNG and provide gas domestic market obligation as stipulated in MoEMR Regulation No.19/2010 on Natural Gas Utilization for Gas Fuel in Transportation Sector.

This simulation discusses the effect of energy diversification on energy consumption behavior and oil import in transportation and electricity generation sector as the largest oil fuel user.

a. Transportation Sector

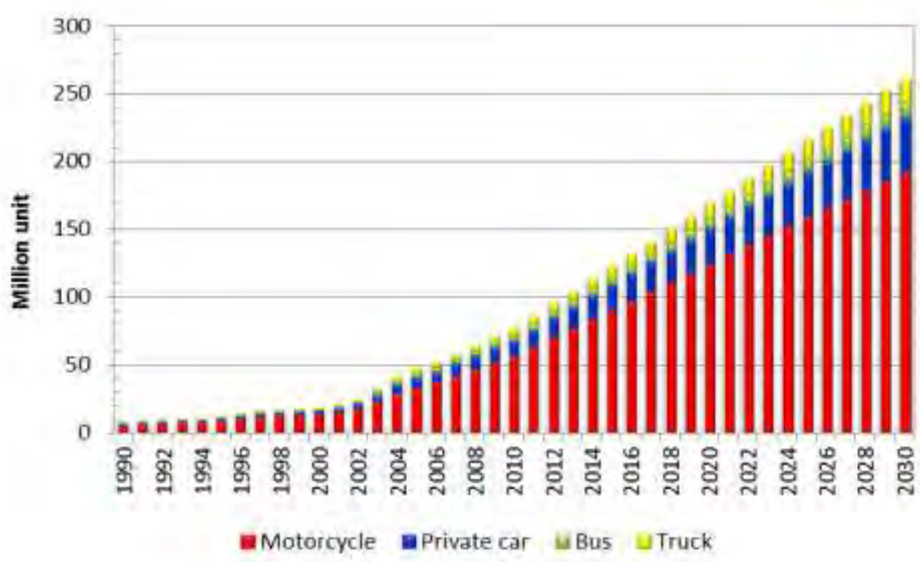
Transportation is the sector with the highest final energy consumption that contributes to the higher cost of subsidy and oil import. BPPT (2010) pointed out that the increasing traffic volume and number of private car also contribute to the high oil fuel consumption.

Number of vehicle is predicted to grow 6 percent per year as presented on Chart 4.23, to the level of 261 million vehicles in 2030 and is predicted to consume 806 million BOE (351 million kiloliters per day), which is over 82 percent of total oil fuel consumed.

The alternative mechanism to reduce oil consumption for transportation sector can be classified into four types (Fergusson *et al*, 2006): (1) the use of more fuel-efficient vehicles, by means of hybrid car technology development, (2) the use of alternative fuels for vehicles, e.g. biofuels and CNG, (3) the more efficient use of fuel in transportation system with emphasis on public transportation and infrastructure, (4) using less vehicles to reduce the amount of fuel needed.

This simulation examines the use of natural gas vehicle (NGV) to reduce the use of oil fuel subsidies in transport system. A natural gas vehicle or NGV is an alternative vehicle which uses compressed natural gas (CNG) or liquefied natural gas (LNG) as a cleaner alternative to other fossil fuels. As for 2013, there are 15 NGV fueling stations operating in Indonesia. The conversion target includes heavy buses, public transportations, trucks, government vehicles, and private cars. The implementation will be in accordance with the Law No.22/2011 on 2012 Budget Article 7 paragraph (4) item (2b), mandates to develop alternative energy such as biofuel and NGV to reduce demand of oil fuel subsidy.

Chart 4.23 Trend of Number of Vehicle



Source: processed data

In this scenario, CNG conversion program will be more intensively conducted since 2014 by gradually converting 10 percent nonmotor vehicle, then increasing the rate by 2.5 percent per year until it reaches 50 percent of all vehicles in 2030. Starting from 2018, the additional cars will use CNG without converter. In the first year, the conversion kits are to be installed on 2.7 million vehicles, so there will be 36 million vehicles or 52 percent of total vehicles will have already consumed CNG.

The fuel consumed by different transportation modes and activities may vary. Energy intensity in transportation sector is calculated based on energy consumption of each activity divided by the activity parameter. This research uses BPPT-MEDI's model of energy intensity in transportation sector (Sugiyono, 2013) as presented on Table 4.16 to determine oil fuel consumption shown on Table 4.17.

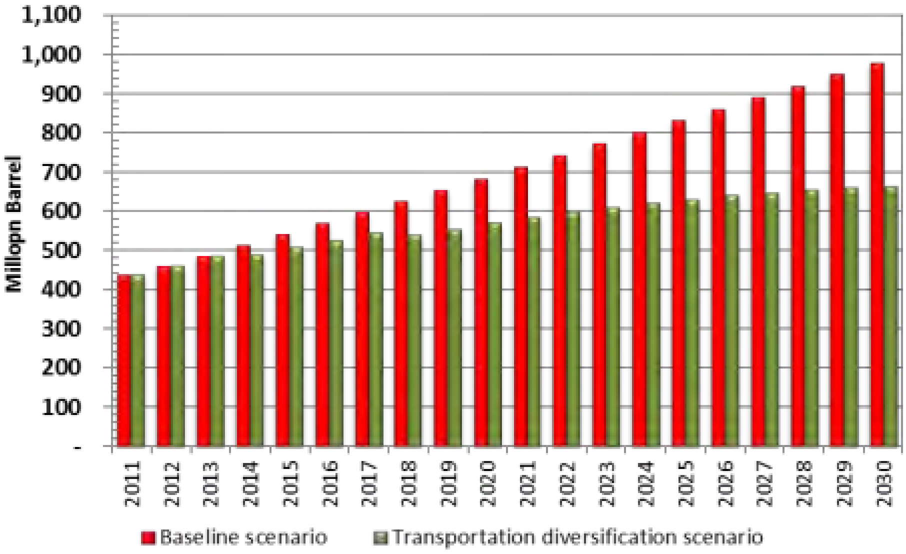
Table 4.16 Energy Intensity in Transportation Sector

Transportation Mode	**Type of Transportation**	**Energy Intensity**	
		Unit	**Value**
Land Transportation	Personal Car	BOE/Unit	6.72
	Bus	BOE/Unit	5.82
	Truck	BOE/Unit	15.65
	Motorcycle	BOE/Unit	1.02

Source: Sugiyono (2013)

The summary of conversion calculation on Table 4.17 presents that oil fuel reduction from 2014 to 2030 are 2,613 million BOE or equivalent to 415 million kiloliters. This research estimates that oil fuel consumption is predicted to be 665 million BOE or decreases by 32.1 percent compared to baseline forecast in 2030 (see Chart 4.24). The value and quantity of oil import are predicted to decrease gradually from 54.2 percent to 29.4 percent compared to the baseline forecast (see Table 4.19).

Chart 4.24 Forecast of Oil Fuel Consumption in Baseline and Transportation Diversification Scenario



Source: processed data

Table 4.17 Calculation of Conversion from Oil Fuel to Compressed Natural Gas

Year	Non-motor vehicle (thousand unit)	Oil fuel demand (ribu SBM)	Cost of subsidy (Trillion rupiah)	NGV conversion (thousand unit)	Reduction Oil fuel demand (ribu SBM)	Cost of subsidy after conversion	Reduction cost of subsidy (trillion rupiah)	Investment on converter kit (trillion rupiah)	CNG demand (thousand barrel oil equivalent)	CNG demand (MMSCFD)	Number CNG station (unit)
2011	22,771	67,813	109.21	-	-	109.21	-	-	181	0.08	-
2012	25,530	75,048	137.28	-	-	137.28	-	-	202	0.09	-
2013	27,861	81,207	163.49	-	-	163.49	-	-	204	0.09	-
2014	30,243	87,502	192.64	2,786	24,887	174.89	17.74	28	8,502	3.88	139
2015	32,665	93,917	224.72	3,780	33,557	198.71	26.00	38	11,394	5.20	189
2016	35,116	100,434	259.71	4,900	43,263	223.48	36.23	49	14,632	6.68	245
2017	37,589	107,038	297.58	6,145	54,025	248.93	48.64	61	18,222	8.32	307
2018	40,077	113,715	338.27	10,006	87,648	253.83	84.44	75	29,432	13.44	500
2019	42,573	120,455	381.71	11,513	100,570	278.49	103.22	90	33,742	15.41	576
2020	45,072	127,249	427.84	13,143	114,551	303.10	124.74	106	38,405	17.54	657
2021	47,570	134,089	476.57	14,893	129,601	327.39	149.18	124	43,425	19.83	745
2022	50,063	140,971	527.82	16,764	145,733	351.10	176.72	143	48,805	22.29	838
2023	52,547	147,890	581.50	18,755	162,957	373.98	207.52	163	54,549	24.91	938
2024	55,020	154,844	637.51	20,864	181,281	395.78	241.73	184	60,659	27.70	1,043
2025	57,479	161,831	695.77	23,092	200,715	416.28	279.49	206	67,140	30.66	1,155
2026	59,922	168,850	756.17	25,435	221,269	435.23	320.94	230	73,994	33.79	1,272
2027	62,348	175,903	818.64	27,893	242,951	452.43	366.20	255	81,225	37.09	1,395
2028	64,755	182,990	883.07	30,464	265,774	467.67	415.40	281	88,835	40.56	1,523
2029	67,142	190,113	949.37	33,146	289,748	480.74	468.63	308	96,830	44.21	1,657
2030	69,509	197,275	1,017.46	35,937	314,888	491.45	526.01	336	105,213	48.04	1,797

Source: processed data

One challenge to make this conversion program running smoothly is government support to provide natural gas supply and infrastructure. The MoEMR has issued Regulation No.19/2010 on the allocation of natural gas to ensure gas supply for CNG, and government has to ensure that this regulation is firmly and consistently implemented. CNG supply is predicted to increase from 8,502 million BOE or equivalent to 3.88 MMSCFD in 2014 to 105 million BOE or equivalent to 48 MMSCFD in 2030.

The government is expected to immediately prepare long-term plan of integrated and available gas infrastructure, such as fuel storage, pipeline, LNG receiving terminal unit, mini LNG, and CNG carriers for delivery and distribution to fueling station from gas sources in remote areas. Thus real-sector economy will grow, create jobs, and reduce oil dependency.

In addition to the necessary supply of gas, the availability of CNG fueling stations is also required. This scenario assumes that one CNG fueling station will serve 20,000 cars and trucks, thus the simulation estimates that government should add more than 139 gas stations in 2014 and increase to 1,800 gas stations in 2030 to serve 36 million CNG. These CNG fueling stations will generate high socio-economic benefits, such as growing sparepart industries, creating jobs, and reducing CO_2 emission.

Using government's assumption (Hartanto et al., 2012), subsidy budget allocation was determined based on number of vehicle consisting 80 percent of passenger cars; 20 percent of truck and buses; and 100 percent of motorcycle. This research estimates that the cost of subsidy in 2030 will be over Rp. 1,017 trillion. Using the assumptions in Table 4.18, the conversion calculation result on Table 4.17 presents that oil fuel consumption will decrease by 25 million BOE (11 thousand kiloliters per day) or equivalent to Rp. 18 trillion reduction cost of subsidy in 2014. Total reduction cost of subsidy until 2030 is predicted to be Rp. 3,592 trillion and requires more investment on converter kits amounting to Rp. 2,676 trillion.

Table 4.18 Assumption of Oil Fuel Conversion to CNG

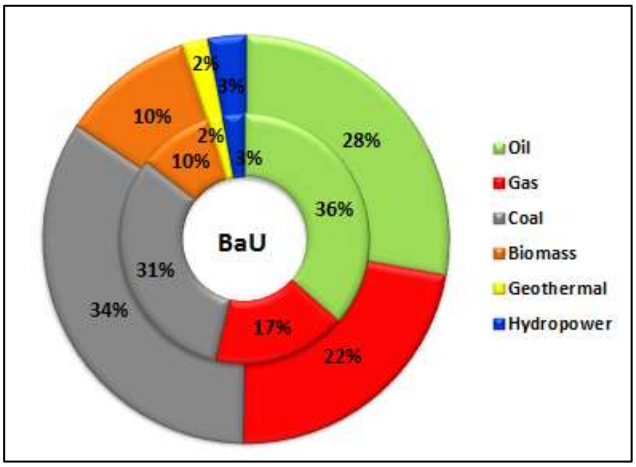
Price of oil fuel subsidy	Rp. 6,500
Price of oil fuel non-subsidy	Rp. 9,000
Price of converter kits	Rp. 10,000,000
Days in a year	365 days

Source: processed data

The implementation of NGV use for transportation will generate huge socio-economic benefits, such as reducing oil dependency by eliminating government's fiscal burden through lower subsidy cost and oil import reduction. The use of natural gas will increase the economy as it costs lower than gasoline up to 30 percent. It is also convenient and safer because the fuel storage tank on NGV is thicker and stronger than gasoline or diesel tank. Moreover, it will reduce environmentally harmful emission while having lower maintenance costs; because natural gas burns cleanly, it results in less wear and tear on the engine and extends the time between tune-ups and oil changes.

Energy diversification in transportation sector will change the share of final energy consumption in 2011 and 2030. Oil fuel consumption is predicted to decrease by 8 percent, while gas consumption increases by 5 percent from the baseline as presented on Chart 4.25.

Chart 4.25 Share of Final Energy Consumption in Baseline and Transportation Diversification Scenario



Source: processed data

These simulation results will be used in preparing the government policy on: (a) investment in upstream sector for gas exploration and exploitation activities, midstream investment on transport and storage natural gas development, and investment in downstream sector on CNG fueling station, (b) incentive for the industries to build network of natural gas fueling stations covering all area in Indonesia, while the additional station at suburban and non-economic area should be provided by the government, (c) providing industry of standardized components that will reduce dependency on converter kit imports, (d) providing incentives on conversion cost for consumers, as performed by Thailand's state-controlled oil company PTT-PCL which provides conversion tools for vehicle owners with payment in stages, which will be billed each time of CNG fueling.

Table 4.19 Forecast of Energy Supply and Demand in Transportation Energy Diversification Scenario

No	Variable name	Code	Unit	2011	2030	Annual growth (%)	Difference to baseline in 2030
1	Consumption of oil fuel at Electricity Generation sector	EGOLT	Thousand barrel	75,751	73,193	-0.1%	0.0%
2	Consumption of oil fuel at Industrial sector	IDOLT	Thousand barrel	45,951	72,884	2.5%	0.0%
3	Consumption of oil fuel at Residential sector	REOLT	Thousand barrel	10,027	6,049	-2.5%	0.0%
4	Consumption of oil fuel at Transport sector	TROLT	Thousand barrel	277,170	491,430	3.1%	-39.1%
5	Consumption of oil fuel at Commercial sector	COMOLT	Thousand barrel	5,817	1,431	-7.1%	0.0%
6	Consumption of oil fuel at Other sector	OCOLT	Thousand barrel	24,816	19,715	-1.2%	0.0%
7	Total of oil fuel consumption	FCOLT	Thousand barrel	439,532	664,701	2.2%	-32.1%
8	Consumption of gas at Electricity Generation sector	EGGT	Thousand barrel	41,479	84,555	3.8%	0.0%
9	Consumption of gas at Industrial sector	IDGT	Thousand barrel	120,257	360,820	6.1%	0.0%
10	Consumption of gas at Residential sector	REGT	Thousand barrel	35,440	81,677	4.5%	0.0%
11	Consumption of gas at Transport sector	TRRTGT	Thousand barrel	181	104,963	224.4%	41805.2%
12	Consumption of gas at Commercial sector	COMGT	Thousand barrel	2,402	12,531	9.1%	0.0%
13	Total of gas consumption	ECGT	Thousand barrel	199,759	644,546	6.4%	19.4%
14	Consumption of coal at Electricity Generation sector	EGCLT	Thousand barrel	189,498	529,991	5.6%	0.0%
15	Consumption of coal at Industrial sector	IDCLT	Thousand barrel	144,567	454,940	6.3%	0.0%
16	Consumption of coal at Residential sector	RECLT	Thousand barrel	108	240	4.3%	0.0%
17	Total of coal consumption	FCCLT	Thousand barrel	334,173	985,171	5.9%	0.0%
18	Consumption of electricity at Industrial sector	IDEGT	Thousand barrel	33,547	52,116	2.4%	0.0%
19	Consumption of electricity at Residential sector	REEGT	Thousand barrel	39,914	223,034	9.6%	0.0%
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22	Consumption of biomass at Residential sector	REBIOT	Thousand barrel	280,171	303,901	0.5%	0.0%
23	Consumption of geothermal at Electricity Generation sector	EGGTT	Thousand barrel	16,494	60,000	7.4%	0.0%
24	Consumption of hydropower at Electricity Generation sector	EGHYT	Thousand barrel	31,269	86,503	5.7%	0.0%
25	Total of energy consumption	ECT	Thousand barrel	1,502,444	3,231,867	4.1%	-6.6%
26	Refinery input	RFCRT	Thousand barrel	321,018	586,079	3.3%	0.0%
27	Refinerry output	OTPPT	Thousand barrel	341,384	553,550	2.7%	0.0%
28	Refinery production - oil fuel product	YBBMT	Thousand barrel	237,135	398,943	2.9%	0.0%
29	Refinery production - non-oil fuel product	YNBBMT	Thousand barrel	104,249	154,607	2.3%	0.0%
30	Import of crude oil	IMCRT	Thousand barrel	96,862	492,035	9.3%	0.0%
31	Import of oil fuel	IMPPT	Thousand barrel	172,113	265,758	2.7%	-54.2%
32	Total of oil import	IMOLT	Thousand barrel	268,975	757,794	5.7%	-29.4%
33	GDP at Electricity Generation sector	EGPT	Trillion Rupiah	11,959	43,833	7.1%	0.0%
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35	GDP at Transport sector	TRPT	Trillion Rupiah	91,797	167,730	3.2%	0.0%
36	GDP at Commercial sector	COMPT	Trillion Rupiah	1,055,281	4,164,849	7.5%	0.0%
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38	Total of GDP	PDBT	Trillion Rupiah	2,463,242	6,133,411	4.9%	0.0%
39	Total of oil import in value	IMV	Trillion Rupiah	263,077	902,182	6.8%	-29.4%
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41	Total enegry consumption at industrial sector	IDECT	Thousand barrel	344,322	940,761	5.5%	0.0%
42	Total enegry consumption at electricity generation sector	EGECT	Thousand barrel	354,491	854,241	4.7%	0.0%
43	Total enegry consumption at commercial sector	COMECT	Thousand barrel	31,555	71,250	4.4%	0.0%
44	Total enegry consumption at transport sector	TRECT	Thousand barrel	277,351	596,393	4.1%	-26.1%
45	Export of crude oil	EXOLT	Thousand barrel	135,572	31,348	-7%	0.0%
46	Export of natural gas	EXGT	Thousand barrel	240,622	168,166	-1.5%	0.0%
47	Export of coal	EXCLT	Thousand barrel	1,145,220	2,193,930	3.6%	0.0%
48	Number of vehicle	VEHI	Unit	85,601	261,296	6.1%	0.0%
49	Production of crude oil	IPOLT	Thousand barrel	335,041	131,898	-5.0%	0.0%
50	Production of natural gas	IPGT	Thousand barrel	542,730	720,000	1.5%	0.0%
51	Production of coal	IPCLT	Thousand barrel	1,483,738	2,948,560	4.1%	0.0%
52	Production of geothermal	IPGTT	Thousand barrel	16,494	59,115	7.4%	0.0%
53	Production of hydropower	IPHYTT	Thousand barrel	31,269	97,645	6.7%	0.0%

Source: processed data

b. Power Generation

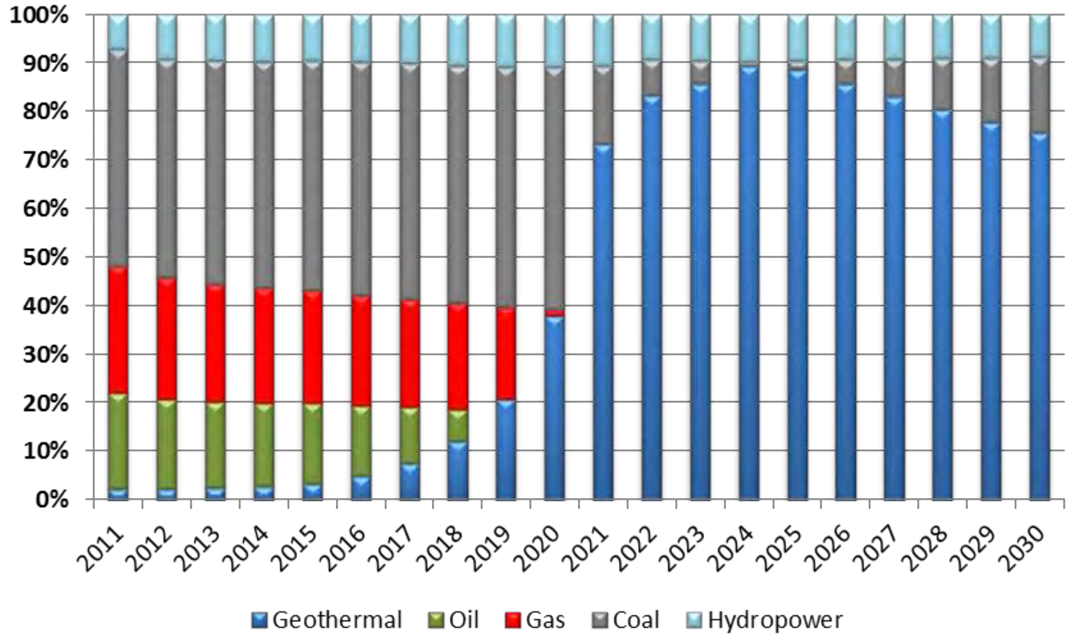
High demand for electricity as a result of the rapid economic growth encourages the need for primary energy source for power plants. Dependency on fossil-based primary energy in power generation sector should be replaced by geothermal as the most promising energy source. Studies have shown that geothermal is more favorable than oil and other alternative energy because of its huge potential in Indonesia (40 percent of the world's geothermal potential), is environmentally friendly and renewable, yet it cannot be exported.

Based on Table 4.1, since 1972 only 4 percent of the potential renewable energy used for power generation in Indonesia has been utilized to increase power capacity in rural areas to replace the use of oil fuel in Diesel Power Center. The problems of renewable energy utilization for electricity generation, according to National Resilience Institute (2012): (1) the price for electricity from renewable energy is not competitive with the price of electricity from other energy due to not adding external costs into account yet, (2) site specific nature, (3) very expensive investment for exploration, drilling, and plant development, (4) no regulation on renewable energy management rising fears of monopoly.

Using basic year of 2011, 1.1 GW of geothermal source's installed capacity (4 percent of the potential 29 GW) can generate electricity of 3.557 GWh or equivalent to 16.5 million BOE. Forecast results on baseline scenario shows that in 2030, there will be the installed capacity of geothermal power plant by 4 GW (14 percent of the potential 29 GW) to generate electricity of 12.939 GWh or equivalent to 60 million BOE.

In this scenario, the optimization of geothermal utilization is simulated until the the installed capacity of 29 GW is spread across 276 geothermal points since the year 2022 to generate electricity of 254.040 GWh or equivalent to 1.178 million BOE. The optimization of geothermal utilization will replace the use of oil fuel in the year 2019 and natural gas in the year 2021 as well as reducing the use of coal for power generation with the same capacity (see Chart 4.26). By 2030, the use of geothermal for electricity generation is 76 percent of total energy needs in power generation sector.

Chart 4.26 Projection of Primary Energy Utilization of Primer for Power Generation of the period from 2011 to 2030



Source: processed data

Compared to the baseline scenario, electricity generated from geothermal in 2030 can reduce the use of fossil energy by 64 percent or equivalent to 537 million BOE, consisting the reduction of oil fuel consumption by 73 million BOE, natural gas by 84 million BOE, and coal by 380 million BOE (see Table 4.20).

Table 4.20 Energy Needs for Power Generation in 2030

	Energy needs for power generation in 2030 (thousand BOE)						
	Oil	Gas	Coal	Geothermal	Hydropower	Total	Remarks
Baseline scenario	73,193	84,555	529,991	60,000	86,503	834,241	
Geothermal diversification	-	-	150,211	1,177,993	86,503	1,414,707	Differences conversion factor

Source: processed data

Table 4.21 shows that the conversion from geothermal and fossil energy for electricity generation will reduce: (a) total oil fuel consumption by 7.5 percent, (b) total gas consumption by 15.7 percent, (c) total coal consumption by 38.5 percent, (d) amount of oil fuel import by 12.6 percent, and (e) value of petroleum import by 6.8 percent.

Although it is limited to certain areas, the use of geothermal has more economic and environmental benefits compared to other energy (Suharno, 2013): (1) It will not run out of usage (renewable and sustainable), (2) The cleanliness of the environment surrounding the power plant remains because it does not produce harmful exhaust gas resulting from combustion, (3) It reduces CO_2 emissions from electricity generation. Through Clean Development Mechanism (CDM), carbon reductions can be sold to provide financial incentives, (4) Compared to other renewable energy, such as solar and wind, geothermal has more power and can be used any time, (5) Compared to hydro power plant (PLTA), geothermal power plant (PLTP) does not have drought problem in the long dry season, (6) Compared to nuclear power plant (PLTN), PLTP does not require waste processing and storage as there is no risk of cancer and DNA mutations, (7) Compared with the energy from the sea, geothermal utilization is cheaper, for it only takes US$ 3,000/kW - US$ 4,000/kW, (8) It has lower operating costs because there is no fuel purchasing and waste handling costs, (9) The cost for electricity from geothermal facilities is decreasing, as in the US where there has been electricity cost reductions for at least 50% since 1980, (10) It keeps the country's foreign exchange because it reduces the cost of petroleum import and subsidies, (11) Even though geothermal is not an export commodity, it can withstand global energy competition as well as fluctuations of world energy price, and (12) It create jobs that will increase the welfare and economic productivity of the surrounding communities.

Table 4.21 Forecast of Energy Demand and Supply in Scenario of Oil Fuel Diversification to Geothermal for Power Generation Sector

No	Variable name	Code	Unit	2011	2030	Annual growth (%)	Difference to baseline in 2030
1	Consumption of oil fuel at Electricity Generation sector	EGOLT	Thousand barrel	63,517	-	-	-100.0%
2	Consumption of oil fuel at Industrial sector	IDOLT	Thousand barrel	45,951	72,884	2.5%	0.0%
3	Consumption of oil fuel at Residential sector	REOLT	Thousand barrel	10,027	6,049	-2.5%	0.0%
4	Consumption of oil fuel at Transport sector	TROLT	Thousand barrel	277,170	806,318	5.8%	0.0%
5	Consumption of oil fuel at Commercial sector	COMOLT	Thousand barrel	5,817	1,431	-7.1%	0.0%
6	Consumption of oil fuel at Other sector	OCOLT	Thousand barrel	24,816	19,715	-1.2%	0.0%
7	Total of oil fuel consumption	FCOLT	Thousand barrel	427,298	906,396	4.1%	-7.5%
8	Consumption of gas at Electricity Generation sector	EGGT	Thousand barrel	45,179	-	3.8%	-100.0%
9	Consumption of gas at Industrial sector	IDGT	Thousand barrel	120,257	360,820	6.1%	0.0%
10	Consumption of gas at Residential sector	REGT	Thousand barrel	35,440	81,677	4.5%	0.0%
11	Consumption of gas at Transport sector	TRRTGT	Thousand barrel	181	250	1.7%	0.0%
12	Consumption of gas at Commercial sector	COMGT	Thousand barrel	2,402	12,531	9.1%	0.0%
13	Total of gas consumption	ECGT	Thousand barrel	203,459	455,279	5.4%	-15.7%
14	Consumption of coal at Electricity Generation sector	EGCLT	Thousand barrel	190,282	150,211	5.6%	-71.7%
15	Consumption of coal at Industrial sector	IDCLT	Thousand barrel	144,567	454,940	6.3%	0.0%
16	Consumption of coal at Residential sector	RECLT	Thousand barrel	108	240	4.3%	0.0%
17	Total of coal consumption	FCCLT	Thousand barrel	334,957	605,391	5.9%	-38.5%
18	Consumption of electricity at Industrial sector	IDEGT	Thousand barrel	33,547	52,116	2.4%	0.0%
19	Consumption of electricity at Residential sector	REEGT	Thousand barrel	39,914	223,034	9.6%	0.0%
20	Consumption of electricity at Commercial sector	COMEGT	Thousand barrel	23,336	57,288	4.8%	0.0%
21	Total of electricity consumption	FCEGT	Thousand barrel	96,797	332,438	6.7%	0.0%
22	Consumption of biomass at Residential sector	REBIOT	Thousand barrel	280,171	303,901	0.5%	0.0%
23	Consumption of geothermal at Electricity Generation sector	EGGTT	Thousand barrel	16,494	1,177,993	29.3%	1863.3%
24	Consumption of hydropower at Electricity Generation sector	EGHYT	Thousand barrel	31,269	86,503	5.7%	0.0%
25	Total of energy consumption	ECT	Thousand barrel	1,494,694	4,022,508	5.4%	16.2%
26	Refinery input	RFCRT	Thousand barrel	321,018	586,079	3.3%	0.0%
27	Refinerry output	OTPPT	Thousand barrel	341,384	553,550	2.7%	0.0%
28	Refinery production - oil fuel product	YBBMT	Thousand barrel	237,135	398,943	2.9%	0.0%
29	Refinery production - non-oil fuel product	YNBBMT	Thousand barrel	104,249	154,607	2.3%	0.0%
30	Import of crude oil	IMCRT	Thousand barrel	96,862	492,035	9.3%	0.0%
31	Import of oil fuel	IMPPT	Thousand barrel	172,113	507,453	6.1%	-12.6%
32	Total of oil import	IMOLT	Thousand barrel	268,975	999,488	7.3%	-6.8%
33	GDP at Electricity Generation sector	EGPT	Trillion Rupiah	11,959	43,833	7.1%	0.0%
34	GDP at Industrial sector	INDPT	Trillion Rupiah	634,247	1,018,624	2.5%	0.0%
35	GDP at Transport sector	TRPT	Trillion Rupiah	91,797	167,730	3.2%	0.0%
36	GDP at Commercial sector	COMPT	Trillion Rupiah	1,055,281	4,164,849	7.5%	0.0%
37	GDP at Other sector	OCPT	Trillion Rupiah	669,959	738,374	0.5%	0.0%
38	Total of GDP	PDBT	Trillion Rupiah	2,463,242	6,133,411	4.9%	0.0%
39	Total of oil import in value	IMV	Trillion Rupiah	263,077	1,189,929	8.4%	-6.8%
40	Total enegry consumption at residential sector	REECT	Thousand barrel	365,660	614,901	2.8%	0.0%
41	Total enegry consumption at industrial sector	IDECT	Thousand barrel	344,322	940,761	5.5%	0.0%
42	Total enegry consumption at electricity generation sector	EGECT	Thousand barrel	346,741	1,414,707	4.7%	65.6%
43	Total enegry consumption at commercial sector	COMECT	Thousand barrel	31,555	71,250	4.4%	0.0%
44	Total enegry consumption at transport sector	TRECT	Thousand barrel	277,351	806,568	5.8%	0.0%
45	Export of crude oil	EXOLT	Thousand barrel	135,572	31,348	-6.9%	0.0%
46	Export of natural gas	EXGT	Thousand barrel	240,622	168,166	-1.5%	0.0%
47	Export of coal	EXCLT	Thousand barrel	1,145,220	2,193,930	3.6%	0.0%
48	Number of vehicle	VEHI	Unit	85,601	261,296	6.1%	0.0%
49	Production of crude oil	IPOLT	Thousand barrel	335,041	131,898	-5.0%	0.0%
50	Production of natural gas	IPGT	Thousand barrel	542,730	720,000	1.5%	0.0%
51	Production of coal	IPCLT	Thousand barrel	1,483,738	2,948,560	4.1%	0.0%
52	Production of geothermal	IPGTT	Thousand barrel	16,494	59,115	7.4%	0.0%
53	Production of hydropower	IPHYTT	Thousand barrel	31,269	97,645	6.7%	0.0%

Source: processed data

4.5.7. Simultaneous Simulation for Energy Demand and Petroleum Import

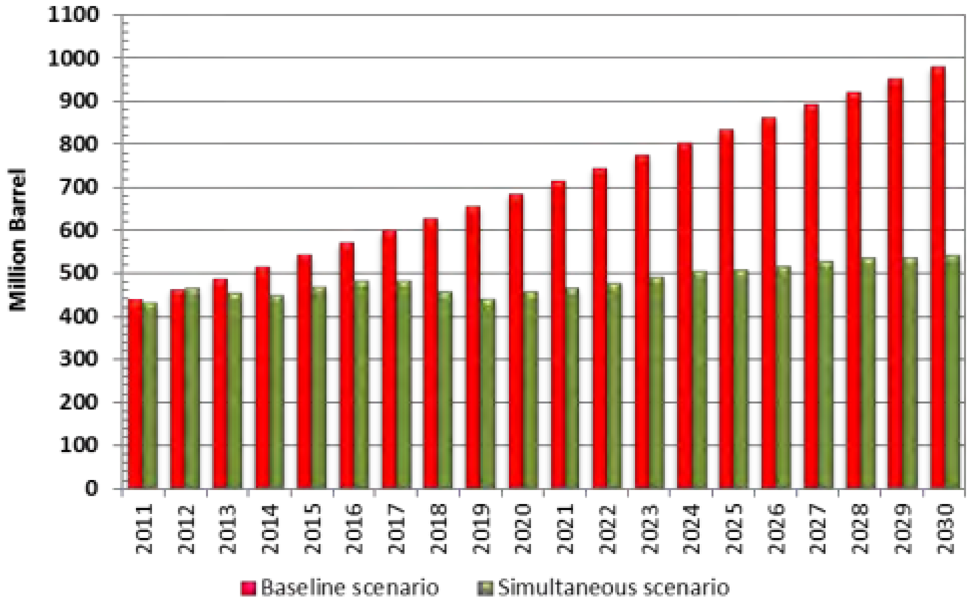
It is a combination of scenarios to reduce dependence on oil, i.e. scenario of the increasing price of subsidized oil fuel in 2013 which rises gradually every 4 years by adjusting international oil price. It is followed by the increasing crude oil production by 1 million barrels per day in 2014 and the gradually increasing refinery efficiency up to 95% in 2030. It is also in parallel with oil fuel conversion program to CNG starting in 2014 and optimization of geothermal utilization for power generation.

The simulation result on Table 4.22 shows that:

1. Total oil fuel consumption reduces by 44.9 percent compared to the baseline scenario (see Chart 4.27). The rising fuel price since 2013 reduces oil fuel consumption in all sectors, leading to an increase in oil fuel conversion to CNG, thus decreasing oil fuel consumption in transportation sector up to 42.9 percent. The increasing oil fuel price encourages the optimization of geothermal power plant, so that oil fuel consumption in power generation sector is reduced to 100 percent in 2030.
2. The amount of crude oil import rises by 15.3 percent because the increasing crude oil production in 2014 still has not been able to fulfill refinery needs which efficiency also increases to 95 percent.
3. The amount of oil fuel import is reduced by 88.5 percent due to its consumption in all sectors is reduced as a result of the rising price of subsidized oil fuel followed by its conversion to CNG beginning in 2014, the

optimization of geothermal utilization for power generation, and the increasing oil fuel production from domestic refineries.

Chart 4.27 Projection of Oil Fuel Consumption in Baseline and Simultaneous Scenario of the period from 2011 to 2030



Source: processed data

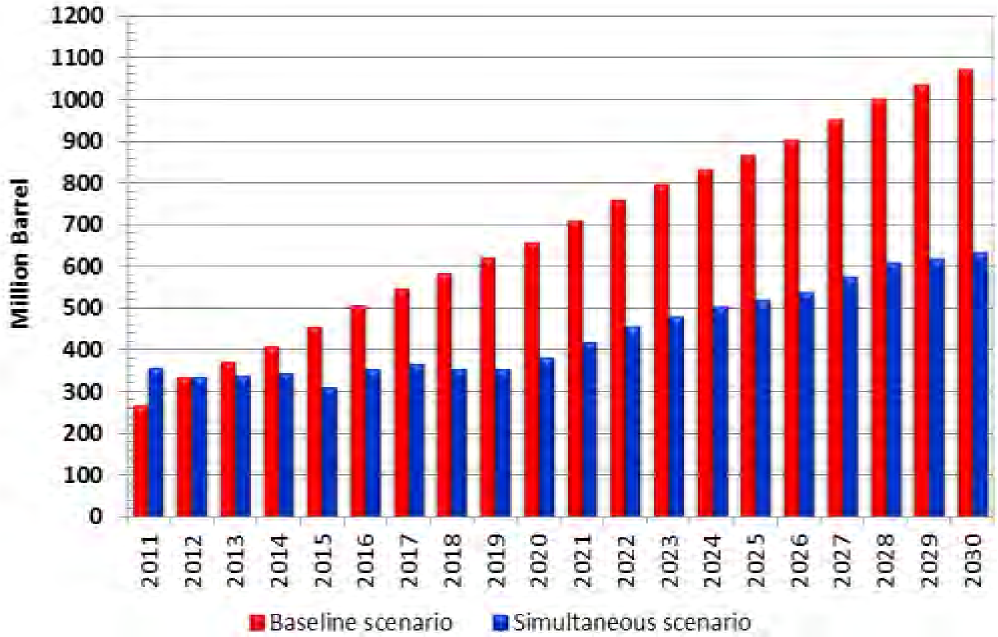
4. The imports value for both crude oil and oil fuel are expected to be reduced by 40.9 percent in 2030 compared to the baseline scenario due to the reduction of oil fuel imports in large amount.
5. There are a mixed energy replacing dependence on petroleum and other energy types, namely gas and geothermal. In simultaneous scenario, this mix of energy consumption in 2030 is dominated by geothermal amounting 34 percent. The rest of the consumption mix is 21 percent petroleum, 16 percent natural gas, 18 percent coal, 9 percent biomass, and 2 percent hydropower.

Table 4.22 Forecast of Energy Demand and Supply in Simultaneous Scenario for the period of 2011 and 2030

No	Variable name	Code	Unit	2011	2030	Difference to baseline in 2030
1	Consumption of oil fuel at Electricity Generation sector	EGOLT	Thousand barrel	63,517	-	-100.0%
2	Consumption of oil fuel at Industrial sector	IDOLT	Thousand barrel	50,403	59,877	-17.8%
3	Consumption of oil fuel at Residential sector	REOLT	Thousand barrel	8,515	6,049	0.0%
4	Consumption of oil fuel at Transport sector	TROLT	Thousand barrel	277,170	460,181	-42.9%
5	Consumption of oil fuel at Commercial sector	COMOLT	Thousand barrel	5,888	-	-100.0%
6	Consumption of oil fuel at Other sector	OCOLT	Thousand barrel	25,463	16,427	-16.7%
7	Total of oil fuel consumption	FCOLT	Thousand barrel	430,956	539,362	-44.9%
8	Consumption of gas at Electricity Generation sector	EGGT	Thousand barrel	45,179	-	-100.0%
9	Consumption of gas at Industrial sector	IDGT	Thousand barrel	140,370	360,820	0.0%
10	Consumption of gas at Residential sector	REGT	Thousand barrel	36,230	81,677	0.0%
11	Consumption of gas at Transport sector	TRRTGT	Thousand barrel	181	98,539	39240.5%
12	Consumption of gas at Commercial sector	COMGT	Thousand barrel	2,646	12,531	0.0%
13	Total of gas consumption	ECGT	Thousand barrel	224,606	553,567	2.5%
14	Consumption of coal at Electricity Generation sector	EGCLT	Thousand barrel	190,282	150,211	-71.7%
15	Consumption of coal at Industrial sector	IDCLT	Thousand barrel	162,072	466,636	2.6%
16	Consumption of coal at Residential sector	RECLT	Thousand barrel	109	240	0.0%
17	Total of coal consumption	FCCLT	Thousand barrel	352,463	617,087	-37.4%
18	Consumption of electricity at Industrial sector	IDEGT	Thousand barrel	35,493	52,116	0.0%
19	Consumption of electricity at Residential sector	REEGT	Thousand barrel	47,227	223,034	0.0%
20	Consumption of electricity at Commercial sector	COMEGT	Thousand barrel	23,341	57,288	0.0%
21	Total of electricity consumption	FCEGT	Thousand barrel	106,061	332,438	0.0%
22	Consumption of biomass at Residential sector	REBIOT	Thousand barrel	252,019	303,901	0.0%
23	Consumption of geothermal at Electricity Generation sector	EGGTT	Thousand barrel	16,494	1,177,993	1863.3%
24	Consumption of hydropower at Electricity Generation sector	EGHYT	Thousand barrel	31,209	86,503	0.0%
25	Total of energy consumption	ECT	Thousand barrel	1,503,626	3,793,952	9.6%
26	Refinery input	RFCRT	Thousand barrel	321,018	1,286,079	119.4%
27	Refinerry output	OTPPT	Thousand barrel	326,952	1,219,879	120.4%
28	Refinery production - oil fuel product	YBBMT	Thousand barrel	237,135	1,036,777	159.9%
29	Refinery production - non-oil fuel product	YNBBMT	Thousand barrel	89,817	183,102	18.4%
30	Import of crude oil	IMCRT	Thousand barrel	186,057	1,160,688	135.9%
31	Import of oil fuel	IMPPT	Thousand barrel	173,804	(497,415)	-185.7%
32	Total of oil import	IMOLT	Thousand barrel	359,861	663,272	-38.2%
33	GDP at Electricity Generation sector	EGPT	Trillion Rupiah	11,841	43,833	0.0%
34	GDP at Industrial sector	INDPT	Trillion Rupiah	631,024	1,018,624	0.0%
35	GDP at Transport sector	TRPT	Trillion Rupiah	91,772	167,730	0.0%
36	GDP at Commercial sector	COMPT	Trillion Rupiah	1,149,240	4,164,849	0.0%
37	GDP at Other sector	OCPT	Trillion Rupiah	634,058	738,374	0.0%
38	Total of GDP	PDBT	Trillion Rupiah	2,517,936	6,133,411	0.0%
39	Total of oil import in value	IMV	Trillion Rupiah	351,969	789,651	-38.2%
40	Total energy consumption at residential sector	REECT	Thousand barrel	344,100	614,901	0.0%
41	Total energy consumption at industrial sector	IDECT	Thousand barrel	388,337	939,449	-0.1%
42	Total energy consumption at electricity generation sector	EGECT	Thousand barrel	346,681	1,414,707	65.6%
43	Total energy consumption at commercial sector	COMECT	Thousand barrel	31,875	66,647	-6.5%
44	Total energy consumption at transport sector	TRECT	Thousand barrel	277,351	558,719	-30.7%
45	Export of crude oil	EXOLT	Thousand barrel	83,760	42,275	34.9%
46	Export of natural gas	EXGT	Thousand barrel	240,622	168,166	0.0%
47	Export of coal	EXCLT	Thousand barrel	1,131,361	2,167,846	-1.2%
48	Number of vehicle	VEHI	Unit	87,450	261,296	0.0%
49	Production of crude oil	IPOLT	Thousand barrel	335,041	169,101	28.2%
50	Production of natural gas	IPGT	Thousand barrel	542,730	720,000	0.0%
51	Production of coal	IPCLT	Thousand barrel	1,483,738	2,948,560	0.0%
52	Production of geothermal	IPGTT	Thousand barrel	16,494	59,115	0.0%
53	Production of hydropower	IPHYTT	Thousand barrel	31,269	97,645	0.0%

Source: processed data

Chart 4.28 Projection of Petroleum Imports in Baseline and Simultaneous Scenario of the period from 2011 to 2030



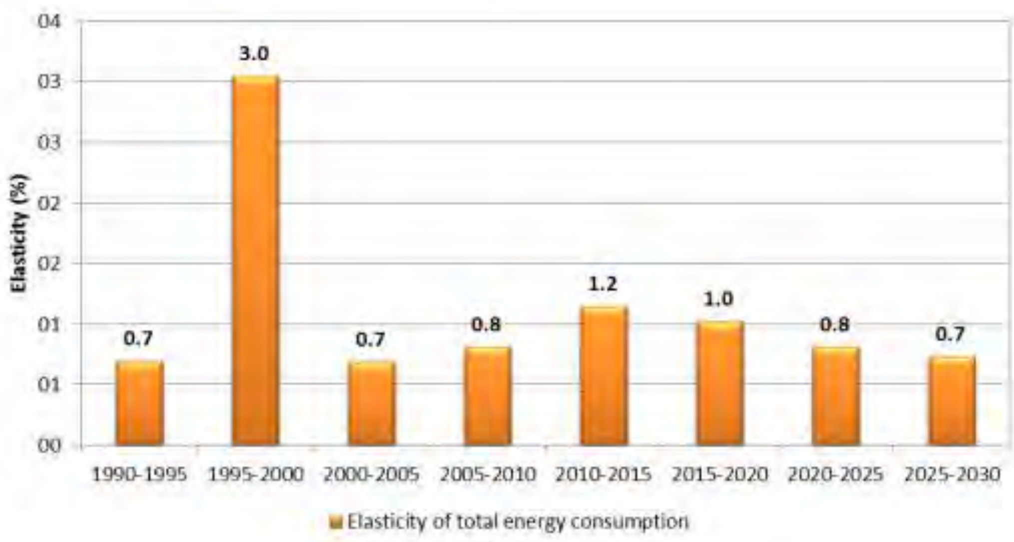
Source: processed data

4.6. Efficiency of Energy Consumption

Elasticity of energy consumption is an indicator used to calculate energy efficiency. The elasticity of energy consumption is defined as the ratio between the growth of final energy consumption and the growth of Gross Domestic Product (GDP). The elasticity of energy consumption is said to be elastic if its value equals one. Meanwhile, the elasticity value greater than one represents inefficient consumption (Yusgiatoro, 2000 and MoEMR, 2006).

In this section, the displayed elasticity of energy consumption is the energy consumption elasticity of five-year period, using historical data from 1990 to 2011 and forecast result from the year 2012 to 2030 based on the models built.

Chart 4.29 Elasticity of Total Energy Consumption



Source: processed data

Based on the development and forecast of total energy consumption elasticity in Chart 4.29, the elasticity of total energy consumption in the period 1995-2000, 2010-2015, and 2015-2020 have values greater than one. The elasticity value means 1 percent increase in GDP will increase the total energy consumption in the period 1995-2000, 2010-2015, and 2015-2020 by 3 percent, 1.2 percent, and 1 percent respectively. This indicates that the total energy consumptions in the periods are not efficient. The inefficiency from 1995 to 2000 was caused by economic crisis occurred in 1998. Indonesia experienced economic decline greater than energy consumption decline.

The improving economic condition after crisis in 1998 and 2008 resulted in the increasing rate of energy consumption to encourage economic activity from the year 2010 to 2020 is faster than the rate of economic growth.

Table 4.23 Elasticity of Sectoral Energy Consumption

Year	Elasticity of sectoral energy consumption				
	Commercial	Power Generation	Industry	Others	Transportation
1990-1995	1.7	1.5	0.7	1.3	1.0
1995-2000	3.3	1.4	6.2	1.4	1.8
2000-2005	0.7	1.3	0.4	1.6	0.6
2005-2010	0.5	0.6	1.2	-0.1	1.8
2010-2015	0.5	1.3	2.3	-1.2	1.7
2015-2020	0.6	0.8	1.9	-1.3	1.8
2020-2025	0.6	0.5	1.7	-3.1	1.7
2025-2030	0.6	0.5	1.5	-6.6	1.7

Source: processed data

Until 2030, industrial and transportation sector still require a lot of energy to boost sectoral revenues. As shown on Table 4.23, the elasticities of energy consumption in both sectors are greater than one. A shift in economic structure towards commercial sector increases revenues in commercial sector. The more efficient energy use in this sector results in the value of energy consumption elasticity less than one.

CHAPTER V

CONCLUSION AND IMPLICATION

5.1 Conclusion

Based on the research results in addressing the problems of the study, the following conclusions can be drawn:

1. The disaggregate analysis of the relationship between the analyzed factors and Indonesia's need of oil import using simultaneous equations show that:
   a. The role of GDP on the need of oil imports through oil fuel consumption has significant correlation and positive relationship in the sectors using oil fuel as the main energy, such as transportation and residential sector. The test on disaggregate level of energy users shows that GDP is statistically significant to the dominant energy type on the sectors.
   b. The role of the subsidized oil fuel price on the need of oil import through oil fuel consumption has significant correlation and negative relationship in all sector energy users, except electricity generation and residential sector due to subsidies and conversion program.
   c. Meanwhile, the role of international oil price has positive relationship and has no significant correlation with the need of oil import through oil fuel consumption. The evidence shows that the increase of international oil price will be followed by the increase of oil import due to oil fuel price subsidy that leads to the increasing oil fuel consumption.

d. The role of crude oil production on the need of oil import has negative relationship and is statistically significant only on crude oil import due to the limited number and specification of crude oil refinery.

e. Oil refinery efficiency has significant correlation with the need of oil import; positive relationship on oil fuel import and negative relationship on crude oil import.

f. The role of energy shifting from oil into non-oil energy on energy diversification has negative relationship and significant correlation with the need of oil import through oil fuel consumption.

2. The estimation of Indonesia's energy demand until 2030 using STEPAR method suggests:

   a. The increase of energy consumption (4.9 percent per year) is slightly lower compared to GDP growth, indicating that the structural economic change is still in progress, from industrial sector to commercial sector.

   b. The consumption of oil fuel is predicted to increase by 4.3 percent per year along with the growth of economic and population, but the consumption of oil fuel begins to be shifted by other energy types in the long term due to the increasing oil price subsidy and government policy related environmental issues.

   c. Indonesia's primary energy supply will continue to be dominated by fossil fuels (coal at 73 percent, 19 percent of natural gas, 3 percent of oil, and 5 percent of renewable energy). Unfortunately, its abundant and varied energy resources have not been fully utilized for domestic needs considering the next generation needs, causing fear of deficiencies of domestic energy supply and national security. Of the total energy produced, 77 percent of coals and 44 percent of gas are for exports, and only 4 percent of renewable energy potential will be developed.

d. The energy term of trade indicates that Indonesia would be a net energy importer starting from 2015 due to improper pattern of energy allocation. Indonesia's energy consumption is not adapted to its natural resources endowment that may cause fear of significant burden on the balance of payment and national security. The most widely consumed energy is oil, in which 80 percent of it is obtained from imports, while coal and gas are exported at cheaper prices than the imported oil and other renewable energy development are ignored.

3. The above results of the factors determining oil import were used to generate various alternative strategies to deal with oil dependency and energy demand in 2030. The simulation suggests:

a. The effort to reduce oil dependency will provide optimum result if conducted simultaneously.

b. The effort to reduce oil dependency should be focused on transportation sector as the highest oil fuel user by implementing the use of CNG which will reduce oil fuel consumption and import by 32 percent, reduce cost of subsidy by Rp. 3,592 trillion until 2030, reduce CO_2 emission, and increase the economy as it costs lower than gasoline. Moreover, it generates value added and job employment in the sector of upstream and downstream in CNG fueling station industries.

c. The effort to maintain the secure and sustainable energy in Indonesia should be conducted by optimizing the use of geothermal as renewable energy in power generation sector. The simulations shows that the optimization of geothermal utilization will replace the use of fossil fuel in the year 2019, reduce the use of fossil fuel by 64 percent and oil import by 7 percent, withstand global energy competition as well as fluctuations of world energy price due to not being an export-import commodity, generate value added and job employment in geothermal industries that will increase the welfare and economic productivity of surrounding communities, reduce CO_2 emissions from electricity generation, and other environmental benefits compared to other energy which make it sustainable.

5.2 Research Limitation

Limitation of this study lies in research model and the forecast assumption, such as:

1. Environmental externalities variables such as negative impact on the environment related directly to the extraction and use of fossil fuels, and trade-off between technological progress and resource exhaustibility are not taking into account on the model and discussion.

2. Non-economic variables such as global and national politics changes, technological changes, labor structure changes which occurred during research and forecasting period are not taking into account on the model and discussion.
3. Limited data of new and renewable energy consumption, such as biofuel, biogas, and municipal solid waste consumption, makes it not included into the model. The energy data source refers to the published report by Ministry of Energy and Mineral Resources.

5.3 Research Implication

Research result and findings are expected to provide theoretical and strategic implications. This section will present some implications of research result.

5.3.1 Theoretical and Methodological Implications

Although the research methods used in this research are not new, they were combined in ways that had not been done previously. In particular, the analysis method started with the model structure that was adopted from IEA's world energy model (2011). The model was modified by incorporating non-fossil energy into energy supply block, which was previously only for fossil fuel. This obtains a more targeted research goal, which is to analyze renewable and non-renewable energy supply and demand at disaggregate level.

In addition, the findings also contribute to the theories and previous researches, including:

1. Findings at disaggregate level of this research reveal interesting differences between sector energy users and energy types in estimating the relationship between GDP and oil fuel consumption, there are:
    a. GDP will have statistically significant correlation with oil fuel consumption only in the sectors that uses oil as their main energy, such as transportation sector (Lestari and Adam, 2008) and residential sector before conversion program was applied in 2005.
    b. GDP will determines energy demand in a country through the most dominant energy consumed in a sector energy user, whereas previous studies investigated this relationship in aggregate level (Apergis and Danuletiu, 2012; Adebola, 2011; Lau *et al.*, 2011; Chary and Bohara, 2010; Siddiqui, 2010; Imran and Siddiqui, 2010; and Stern, 2000).
2. Previous researches suggested that the subsidized oil fuel price has significant and negative relationship with oil fuel consumption (Matheny, 2010; Kirana, 2005; Marks, 2003; and Lewis, 1993). Combined with these prior findings, this result provides additional evidence that the recent increasing price of subsidized oil fuel will decrease oil fuel consumption, furthermore to oil import, if there are no government's policy intervention such as subsidy and conversion program.
3. This result confirms the similar studies by Tefera (2012) and McLure (2013) that international oil price has positive relationship and no significant correlation with oil fuel consumption, furthermore with the need of oil import, to the countries with subsidized oil fuel price policy. Different results

were found in the countries that had removed the subsidy policy, as previously reported by Hamilton (2012), James (2012), Meier *et al.* (2012), Ghosh (2009), Nourah (2005), and Boug (2000).

4. The results found that the increasing or declining crude oil production and reserves in Indonesia as a net oil importer-exporter country and has limited number and specification of refineries will give an impact on the increase in the number of oil import. Provide additional contribution to the previous studies in net oil importer countries by (2010), GSI (2010), Adams and Shachmurove (2007), and Kirana (2005).
5. The finding also provides additional contribution to the evidence of Duangjai *et al.*, (1996) that the policy of energy diversification will affect the need of oil import through oil fuel consumption only in the sectors that are subjected to the policy.

5.3.2 Strategic Implications

The result of this research gives some recommendations for Indonesia's policy implementation in energy security and economy:

1. In generally, to meet the growing energy demand in the long run, Indonesia should take various measures for efficiency improvement in energy use such as minimizing oil subsidies and replace oil subsidy to non-oil subsidy, enhancing NGV conversion program in transport sector, enhancing crude oil supplies through increased domestic explorations and production in foreign oil fields by Indonesian oil companies to avoid excessive dependence on

imported crude oil, increasing refinery capacity and efficiency to support domestic crude oil production, and more vigorously pursue the use of renewable energy sources like geothermal, hydro, wind, solar, bio-fuels, nuclear. Careful planning to ensure that future petroleum requirements can be met will be crucial in sustaining rapid economic growth in the future. Indonesia also should take measures to increase exports to be able to meet its growing future oil import requirements and exporting energy wisely.

2. The research findings indicate that the increasing international oil price does not decrease oil import for a net oil importer which applies oil subsidy policy. It implies that government has to change the paradigm of energy subsidy policy by replacing oil fuel subsidy into non-oil fuel subsidy, followed by shifting paradigm from fossil energy subsidy into non-fossil energy subsidy. Thus, the new and renewable energy is not only as an alternative but also has competitive economic value compared to fossil fuels.
3. The research findings on the increasing oil refinery efficiency which responded differently –decreases oil fuel import but increases crude oil import-- implies that government has to improve domestic oil fuel security in upstream and downstream sectors. For example, developing new refineries with high technology that are appropriate to any kind of crude oil specification in downstream sector, parallel with increasing domestic crude oil production as a refinery input through intensive exploration and exploitation activities in upstream sector.

4. Forecast result which pointed out that Indonesia will be a deficit energy country in 2015 due to the higher value of oil imports than the other exported energy implies to the government's task in improving energy allocation pattern. This condition allows a more efficient resource allocation which will lead to the gains from trades and resources; provide policies to adjust the consumed energy, such as renewable energy, coal, and natural gas. Hence, fossil energy would be dedicated for domestic need rather than export.
5. Simulation result suggests that a number of benefit obtained from diversification program in transportation sector have implications in formulating integrated energy policy and automotive industry. The availability of gas supply and infrastructure, conversion facilities, and gas station would ease people to switch their vehicle using NGV.
6. The simulations results also suggest that national energy security can be achieved by utilizing the potential renewable energy owned, such as geothermal. Hence, natural resource endowments can gain comparative advantages that need to be managed effectively and efficiently in order to be competitive advantages.
7. The results shows that energy supply is not only for meeting consumers' demand to produce products, but also for increasing value added and creating jobs in industry of mining and mineral, power generation, oil and gas refinery, and automotive manufacturing. It will affect the policy formulation on priority development of domestic industry supported by the development of human resources and infrastructures.

5.4 Further Research Recommendations

Based on research results and limitations, some recommendations for further research are as follows:

1. Include the use of renewable and new energies, such as solar, biogas, biodiesel, and urban waste so that the development of energy mixed in Indonesia can be analyzed.
2. Include non-economic variables, such as political condition and the change of labor structure to obtain more comprehensive result.
3. The research findings show that oil fuel consumption is not affected by international oil price due to government's subsidy, thus shock moment analysis is not included in the research. It is suggested that further research makes the analysis of international oil price shock moment using different models.
4. The technology required for the development of energy industry is not analyzed in this study, so further research is recommended to look at the impact and analysis of energy sector development on technology, economy, and labor structure in Indonesia.

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