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Two Essays on Energy Security Evaluation of the Republic of Indonesia

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Abstract

Energy security is a concept that has become increasingly popular, as most policy makers, entrepreneurs, and academics claimed to have pursued it when proposing or implementing changes in the energy domain. It is an important goal of energy policies in many countries while considering the complex factors, such as high energy prices, increased demand and competition for geographically concentrated resources, resource scarcity and/or depletion, and concerns with the effects of climate change.

In this study, we intend to clarify both the meaning and importance of energy security in Indonesia, as well as discuss the strategies or policy alternatives to support it. The demand for energy in Indonesia has increased due to its strong economic growth. Challenges, such as increasing the availability, accessibility, and affordability of energy resources, need a clear and comprehensive energy policy strategy and framework based on an appropriate energy mix. Therefore, a more comprehensive measure of energy security would help policy makers in creating better policy decisions.

In the first part of the study, we illustrated the importance of energy in Indonesia's economy and highlighted how some of the particular characteristics of this area actually explained the increasing interest in this issue. In the second part, we applied the index method on the existing data from 2000 to 2012. In the third part, we evaluated the Gas Supply Security Index of Indonesia's gas market regions based on the Indonesia Gas Balance documents. The last part is the general conclusion of the three

previous parts.

This dissertation contributes to the literature on the measurement of energy security of Indonesia. Our specific contributions are the following:

a. Providing metrics by evaluating a set of parameters and indicators to assess the variation of Indonesia's energy security performance over time from 2000 to 2012.
b. Providing metrics by evaluating a set of parameters and indicators to assess the overall natural gas supply security of Indonesia's domestic gas market. It is important for future policy making to serve as a benchmark against quantified indicators, and assess the gas security of supply weakness.

Keywords: Energy security, Energy security index, Policy analysis, Indonesia

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1. Introduction

1.1. Motivation

Energy security is a concept that has become increasingly popular, as most policy makers, entrepreneurs, and academics usually claim that they pursue it when proposing or implementing changes in the energy policy studies. It is an important goal of energy policies in many countries while considering complex factors, such as high energy prices, increased demand and competition for geographically concentrated resources, resource scarcity and/or depletion, and concerns with the effects of climate change. For example, the European Commission (2006, 2008) stated that the three pillars of the European Union’s energy policy are efficiency, sustainability, and security of the energy supplies. Concerns about energy security first arose in the early 1970s in Europe, Japan, and the United States when the first oil crisis revealed the vulnerability of developed economies to oil price shocks. This actually explains the establishment of the International Energy Agency (IEA) within the OECD.

The term is not clearly defined despite the importance of energy security in the energy policy. There is no common interpretation for energy security (Cecchi et al., 2009). According to Loschel, Moslener, and Rubbelke (2010), the concept of energy supply security, or simply called energy security, seems to be rather blurred. Other authors, such as Mitchell (2002), Kruyt, van Vuuren, de Vries, and Groenenberg (2009), also claim that the concept is elusive. Similar to the others, Chester argues that the concept of energy security is difficult to define. Hence, not many research has been made to clarify the concept of energy security (Chester, 2010).

The aim of this study is to discuss energy security evaluation of Indonesia in the past and in the future, as well as provide some policy analysis, accordingly. We seek to develop a quantitative evaluation method of energy security that is practical and suitable to the case of Indonesia. It should consist of a set of indicators that cover the core aspects of energy security. The study will provide an overview of the conceptual landscape of energy security concepts that allows for selecting and combining different concepts into quantifiable measures, and uses a method that will measure the energy security of Indonesia.

1.2. Research Purpose

This study seeks to answer the following research questions:

a. How has Indonesia's energy security situation evolve over the years?

b. What are the factors that affect the energy security of Indonesia?

c. What factors affect Indonesia's Gas Security of Supply?

To answer these questions, two essays are written in this study. First, Chapter 3 will provide an overview of Indonesia's recent energy security situation and some basic indicators that are relevant and generally used in a more traditional concept of energy security evaluation. Then, the first essay will discuss the energy security evaluation method in order to measure the performance of Indonesia's energy security during the past few years by using the index method. The second essay will evaluate Indonesia's Gas Supply Security Index based on the country's gas balance document. Based on the results, the policy implications will be drawn with regard to the energy security situation.

Chapter 3 provides an overview on Indonesia's energy security situation by presenting the current energy policy framework, energy scenarios, and energy security indicators to show that the task to secure sufficient energy supply will become even more challenging.

Indonesia is one of the countries in Asia Pacific with a fast growing economy. It considers the energy supply security as an important factor for its development. The country's energy consumption heavily depends on crude oil, coal, and natural gas as non-renewable sources of energy. Utilization of the fossil fuel continuously contributes to the huge amount of greenhouse gas emission that leads to climate change.

As a result of experiencing such an unfavorable situation, the government of Indonesia prioritizes on energy supply securities through the diversification of energy resources. The Indonesian Government tries to cope with this situation by issuing Regulation No. 5/2006, which aims for an energy mix of 20% oil, 30% gas, 33% coal, and 17% renewable resources by 2025. Out of the 17% renewable resources share, 5% is biofuel, 5% is geothermal energy, 2% is coal liquefaction, and the remaining 5% is from biomass, nuclear power, hydropower, and solar energy.

Indonesia's energy consumption depends on crude oil, coal, and natural gas as non-renewable sources of energy. Even though Indonesia has relatively abundant energy sources, which mostly come from oil, coal, and natural gas, they will eventually run out someday. In addition, the utilization of fossil fuel continuously contributes to the rising greenhouse gas emission.

Based on the depletion of fossil fuel reserves and the adverse effects of greenhouse gas emission, renewable energy development and utilization should be considered. Indonesia is blessed with great potential for renewable energy, such as solar, wind, micro hydro, and biomass energies. Although the country has applied and extended the utilization of renewable energy, its contribution in power generation is approximately 3%. The government must pay more attention to the utilization of renewable energy.

The first essay discusses the method of evaluating energy security in Indonesia during the past several years. The historical change of energy security index can provide useful lessons for policy development. Although energy security is an important goal of the policy, there are no empirical studies conducted by the government of Indonesia to measure and evaluate its energy security situation. Some studies have included Indonesia energy security index on their study case. Sovacool, Mukherjee, Drupady, and D'Agostino (2011), as well as Sharifuddin (2014), discussed the index method to measure the energy security of several countries. Prambudia and Nakano (2012) used a system dynamic method to measure the energy security of Indonesia. The three studies mentioned above discussed more on establishing an evaluation tool, and put less emphasis on the energy security discussion of the countries included in their case studies.

Most studies conceptualize energy security in terms of oil supply security (Fried and Trezise, 1993; Stringer, 2008). However, Victor and Yueh (2010) found that there has been a shift in the energy security concept. The paradigm of energy security for the past three decades was too limited; therefore, it must be expanded in order to include new factors (Yergin, 2006). Moreover, the author emphasized that energy security does not stand by itself, but rather lodged in the larger relations among nations and how they interact with one another.

Therefore, the substance of these challenges needs to be incorporated into a new concept of energy security. With increasing global, diverse energy markets, as well as increasing transnational problems resulting from energy transformation and use, old energy security rationales are less salient, while other issues, including climate change and other environmental, economic, and international considerations, are becoming increasingly important. As a consequence, a more comprehensive definition of energy security is necessary, along with a workable concept for analysis and measurement of the energy security.

In the case of Indonesia, the demand for energy has increased due to its strong economic growth. Challenges, such as increasing the availability, accessibility, and affordability of the energy resources, need a clear and comprehensive energy policy strategy and framework. Therefore, a measure of energy security would help policy makers in creating better policy decisions. The study is significant to policymakers and the government of Indonesia, as the findings and results of this study will provide valuable insights and a more reliable guide for understanding and measuring the multiple dimensions of energy security based on historical energy indicators.

The second essay evaluates a set of gas supply security indicators, including gas intensity, net gas import dependency, and ratio of domestic gas production to total domestic gas consumption, for several regions in Indonesia's Natural Gas Balance 2015 - 2030 (MEMR, 2015). It proposes a composite gas supply security index (GSSI) based on the method used by Gnansounou (2008). The four gas supply security indicators are interrelated, and the GSSI derived provides a composite quantitative measure of gas security by taking into account the interactions and interdependence among the identified set of indicators. The GSSI captures the sensitivity of the domestic gas market, with a higher index indicating a higher gas supply insecurity or vulnerability for a specific region.

This paper is important in terms of providing metrics by evaluating a set of parameters and indicators to assess the overall natural gas supply security in several domestic gas markets of Indonesia. It is important for future policy making to serve as a benchmark against quantified indicators and assess the gas security of supply weakness.

1.3. Thesis Outline

Chapter 1
Introduction

Chapter 2
Literature Review

Chapter 3
Provides overview and basic analysis of Indonesia's energy security

Quantitative Essays	
Chapter 4	**Chapter 5**
Evaluation of Indonesia's energy security using index method	**Evaluation of Indonesia's Gas Supply Security Index**

Chapter 6
General Summary

The study is organized into six chapters. Chapter 1 gives the introduction of the study. Chapter 2 provides a review of the relevant literature on the energy security measurements as the basis of the three essays in the next three chapters. Chapter 3 provides an overview on Indonesia's energy security situation. Chapter 4 provides a first essay on the evaluation of Indonesia's energy security by using an index method. Chapter 5 provides the second essay, which evaluates Indonesia’s Gas Supply Security Index. Finally, Chapter 6 will provide a general summary of all essays.

2. Literature Review

2.1. Energy Security Definition

Energy security is a complex field of research that extends beyond a range of core issues, such as availability and affordability, to include a number of other related issues such as economic, environmental, technological, risk management, social and geopolitical.

Despite the high importance of energy security in policy, many researchers argued that the definition of energy security is not clearly defined. According to Loschel et al. (2010), the concept of security of energy supply, or in short form energy security, seems to be rather blurred. This argument is supported by Checchi et. al (2009) who claim that there is no common interpretation of energy security. Kruyt et al. (2009) and Mitchell (2002) argue that the concept is elusive. Another author claims that it is difficult to define (Chester, 2010). The notions of energy security can either be so narrow that they neglect the comprehensiveness of energy challenges, or so broad that they lack precision and coherence. According to Sovacool and Brown (2010), to measure energy security by using contemporary methods in isolation such as energy intensity or electricity consumption per capita is like trying to drive a car with only a fuel gauge, or to seeing a doctor who only checks your cholesterol. Table 2.1 shows various definitions of energy security from several studies.

Table 2.1 Energy Security Definitions

Title	Author (Year)	Definition
Energy security as a rationale for governmental action	Andrews (2005)	Energy security is to assure adequate, reliable supplies of energy at reasonable prices and in ways that do not jeopardize major national values and objectives.
Energy security: externalities and policies	Bohi and Toman (1993)	Energy insecurity can be defined as the loss of welfare that may occur as the result of a change in price or availability of energy.
Long-term energy security risks for Europe: a sector-specific approach	Checchi et al. (2009)	Although there is no common interpretation, it is possible to identify a number of features that are always included, namely physical availability and price.
Supply security and short-run capacity markets for electricity	Creti and Fabra (2007)	In the short-term, supply security requires the readiness of existing capacity to meet the actual load.
Green Paper—towards a European strategy for the security of energy supply	European Commission (2000)	Energy supply security strategy must be geared to ensuring, for the well-being of its citizens and the proper functioning of the economy, the uninterrupted physical availability of energy products on the

		market, at a price which is affordable for all consumers (private and industrial), while respecting environmental concerns and looking towards sustainable development.
Diversity and security in UK electricity generation: The influence of low-carbon objectives	Grubb, Butler, and Twomey (2006)	Security of supply can be defined as a system’s ability to provide a flow of energy to meet demand in an economy in a manner and price that does not disrupt the course of the economy.
A quest for energy security in the 21st century.	APERC (2007)	Energy security is the ability to guarantee the availability of energy resource supply in a sustainable and timely manner with the energy price being at a level that will not adversely affect the economic performance of the economy
Long-term energy services security: What is it and how can it be measured and valued?	Jansen and Seebregts (2010)	Energy (supply) security’’ can be considered as a proxy of the certainty level at which the population in a defined area has uninterrupted access to fossil fuels and fossil-fuel based energy carriers in the absence of undue exposure to supply-side market power

		over a period ahead of 10 years or longer.
The analysis of security cost for different energy sources.	Jun, Kim, and Chang (2009)	Energy security can be defined as a reliable and uninterrupted supply of energy sufficient to meet the needs of the economy at the same time, coming at a reasonable price.
Indicators for energy security	Kruyt et al. (2009)	Elements relating to security of supply: availability (or elements relating to geological existence); Accessibility (or geopolitical elements); Affordability (or economical elements); Acceptability (or environmental and societal elements).
Measuring the security of external energy supply in the European Union.	Le Coq and Paltseva (2009)	Supply security usually defined as a continuous availability of energy at affordable price.
Measuring the energy security implications of fossil fuel resource concentration.	Lefevre (2010)	Energy insecurity can be defined as the loss of welfare that may occur as a result of a change in the price or availability of energy.
Assessing reliability in energy supply systems.	McCarthy, Ogden, and Sperling (2007)	Security includes the dynamic response of the system to unexpected interruptions, and its ability to endure them. Adequacy refers to the ability of

		the system to supply customer requirements under normal operating conditions
Gas supply security in the baltic states: a qualitative assessment	Noel and Findlater (2010)	Security of supply (or gas supply security) refers to the ability of a country's energy supply system to meet final contracted energy demand in the event of a gas supply disruption.
A new energy security paradigm for the twenty-first century	Nuttall and Manz (2008)	Interruption of the energy supply identified as the primary threat that faces global energy security.
Contribution of renewables to energy security	Olz et al. (2007)	Energy security risk is the degree of probability of disruption to energy supply occurring.
Linking consumer energy efficiency with security of supply.	Rutherford, Scharpf, and Carrington (2007)	Energy security refers to a generally low business risk related to energy with ready access to a stable supply of electricity/energy at a predicable price without threat of disruption from major price spikes, brown-outs or externally imposed limits.
EU standards for security of supply	Scheepers et al. (2007)	A security of supply risk refers to a shortage in energy supply, either a relative shortage, i.e. a mismatch in

		supply and demand inducing price increases, or a partial or complete disruption of energy supplies. A secure energy supply implies the continuous uninterrupted availability of energy at the consumer’s site.
Russian gas price reform and the EU–Russia gas relationship: incentives, consequences and European security of supply	Spanjer (2007)	Security of supply can broadly be divided into two parts: system security—the extent to which consumers can be guaranteed, within foreseeable circumstances, of gas supply—and quantity security—guaranteeing an adequate supply of gas now as well as in the future. This comprises not only gas volumes, but also price and diversification of gas supplies.
Long-term security of energy supply and climate change. Security of energy supply: comparing scenarios from a European perspective.	Turton and Barreto (2006)	Security is measured as resources to consumption ratio (R/C).
Security of energy supply: comparing scenarios from a European perspective.	Wright (2005)	Energy security is defined as the availability of a regular supply of energy at an affordable price (IEA, 2001). The

Liberalization and the security of gas supply in the UK.		definition has physical, economic, social and environmental dimensions (European Commission (EC), 2000); and long and short term dimensions.'' ''Security of gas supply'': ''an insurance against the risk of an interruption of external supplies.''

Source: Winzer (2012)

According to Winzer (2012), the definition of energy security can be categorized into four groups. First, definitions of energy security that focuses on the continuity of commodity supplies. Scheepers et. al (2007) defines energy security as a security of supply risk refers to a shortage in energy supply, either a relative shortage, i.e. a mismatch in supply and demand inducing price increases, or a partial or complete disruption of energy supplies. A secure energy supply implies the continuous uninterrupted availability of energy at the consumer’s site. Lieb-Dóczy, Börner, and MacKerron (2003) also have similar definition, according to them security of supply is fundamentally about risk. More secure systems are those with lower risks of system interruption. This echoed by Olz et. al (2007) who defines energy security risk as being the degree of probability of disruption to energy supply occurring. IEA report on the interactions between energy security and climate change policy uses an analogous definition of energy insecurity as the loss of economic welfare that may occur as a result of a change in the price and availability of energy.

Another group of study by Wright (2005), Hoogeveen and Perlot (2007) and Department of Energy & Climate Change (DECC) (2009) also has similar definition of energy security. Security of gas supply is an insurance against the risk of an interruption of external supplies (Wright, 2005). Security of supply is a general term to indicate the access to and availability of energy at all times. Supply can be disrupted for a number of reasons, for, example, owing to physical, economic, social, and environmental risks. The most important crises that have been instrumental in shaping the EU's security of supply policy are of a social and economic nature and were all crises in the Greater Middle East region (Hoogeveen and Perlot, 2007). Insecurity of energy supply, in the form of sudden physical shortages, can disrupt the economic performance and social welfare of the country in the event of supply interruptions and/or large, unexpected short-term price increases. Supply interruptions to the gas system are also hazardous in terms of risk of gas inhalation and explosions. No energy form and no source of supply can offer absolute security, so improving security of supply means reducing the likelihood of sudden shortages and having contingency plans in place to reduce the impact of any threats which may occur (DECC, 2009).

Second, definitions of energy security that focuses on the impact measure of the continuity of service supplies. Li (2005) suggests that diversification and localization of energy sources and systems, would provide a security for the energy supply and distribution. Patterson (2008) argues that the energy security concerns supplies of imported oil and natural gas, not the secure delivery of energy services. Noel and Findlater (2010) state that security of supply refers to the ability of a country's energy supply system to meet final contracted energy demand in the event of a gas supply disruption. Hughes (2012) combining the International Energy Agency's definition of energy security with structured systems analysis techniques to create three energy security indicators and a process-flow energy systems model.

Third, definitions of energy security that focuses on the continuity of the welfare or the economy, Lefevre (2010) defines energy insecurity as the loss of welfare that may occur as a result of a change in the price or availability of energy. Grubb et al. (2006) state that security of supply can be defined as a system's ability to provide a flow of energy to meet demand in an economy in a manner and price that does not disrupt the course of the economy. Symptoms of a non-secure system can include sharp energy price rises, reduction in quality, sudden supply interruptions and long-term disruptions of supply. Joode et al., (2004) defines securing the supply of energy as guaranteeing a stable supply of energy at an affordable price, no matter what the circumstances. From an economic point of view, however, the concept of security of supply is less clear. In general economic terms, energy security refers to “the loss of welfare that may occur as the result of a change in price or availability of energy”(Bohi & Toman, 1993).

Fourth, definition of energy security that focuses on the impacts on the environment or the society Kruyt et al. (2009) defines security as an issue dependent on the risk-adverseness of consumers. Its focus is thus not the absolute level of energy prices but the size and impact of changes in energy prices. Verrastro and Ladislaw (2007) emphasize the impact of energy security policy on environment by arguing that the major challenge going forward is to provide adequate, reliable, and affordable energy resources while limiting greenhouse gas emissions and adapting to a changing global climate. European Commission (EC) (2000) states that strategy for energy supply security must be geared to ensuring, for the well-being of its citizens and the proper functioning of the economy, the uninterrupted physical availability of energy products on the market, at a price which is affordable for all consumers (private and industrial), while respecting environmental concerns and looking towards sustainable development.

Although there are various definitions of energy security, there is a common concept behind all energy security definitions, which are the risksof adaptability to threats that are caused by or have an impact on the energy supply. Studies conducted byRutherford et al. (2007), Lieb-Dóczy et al. (2003); Wright (2005); Olz et. al (2007); Keppler (2007) confirm this notion. However, there are a huge number of threats caused by or have an impact on the energy supply chain (Gnansounou, 2008). Since studies on energy security focus on different risk sources or choose different impact measures, the main reason for difference between energy security concepts is on how the authors select which threats they use in their analysis.Individual authors limit their concept of energy security along one or several dimensions due to the difficulty of measuring all of those threats at once. One dimension focuses on the sources of those threats (technical, human and natural). Another dimension focuses on the scope of the impact of those threats.

2.2. Dimensions of Energy Security

The four As of energy security (availability, affordability, accessibility and acceptability) are a frequent starting point of con-temporary energy security studies. Two of the four As (availability and affordability)has been featured in the classic energy security studies (Deese, 1979; Yergin, 1988) and still remain the center of the International Energy Agency's mainstream definition of energy security “as the uninterrupted availability of energy sources at an affordable price” (IEA, 2014). The other two As (accessibility and acceptability) were among the global energy goals proclaimed by the World Energy Council in its Millennium Declaration (WEC, 2000) but were not connected to energy security until the 2007 APERC report.

While there is no universally agreed upon definition of energy security, many dimension sets conform to the three IEA-derived dimensions or can be considered variations on them. This definition can be synthesized into three energy security dimensions: availability (the uninterrupted physical availability), affordability (a price which is affordable), and acceptability (respecting environment concerns). As with the IEA’s definition of energy security being representative of many other definitions, the three indicators (or variations on them) are found in most energy security indicator sets. Table 2.2 below shows some literatures on dimensions of energy security.

Table 2.2 Dimensions of Energy Security

Author (Year)	Dimensions
WEC, 2007	The World Energy Council has three sustainability objectives (the three 'A's) (WEC, 2007): a. Accessibility to modern, affordable energy for all; b. Availability in terms of continuity of supply and quality and reliability of service; and c. Acceptability in terms of social and environmental goals.
APERC, 2007	The four As of energy security (availability, affordability, accessibility and acceptability) are a frequent starting point of contemporary energy security studies. In 2007, APERC used the A-framework, merging the classic availability and affordability with acceptability and accessibility to structure their report on energy security in Asia: a. Availability refers to the availability of oil (and other fossil fuels) and nuclear energy; b. Accessibility considers the barriers to accessing energy resources; c. Affordability of energy (limited to fuel prices, price projections, and infrastructure costs); and d. Acceptability surrounding environmental issues dealing with coal (carbon sequestration), nuclear, and unconventional fuels (biofuel and oil sands).
Kruyt et al. (2009)	Extend the work by Jansen et al. (2004) on the social stability of an energy supplier to Acceptability. Kruyt et al. (2009) grouped their indicators of

	energy security by the four As, which they calleda classification scheme.
Chester (2010)	Mentioned the APERC report in her influential article addressing four dimensions of energy security (availability, adequacy, affordability, and sustainability), similar, but not identical, to the four As. She argued that the concept of energy security was slippery (i.e. impractical to universally define or conceptualize) and multi-dimensional. Subsequently many studies have conceptualized energy security by liberally adding or modifying dimensions to the four As.For example,Hughes (2012)generic framework for the description and analysis of energy security contains three indicators: availability, affordability and acceptability.
Sovacool and Mukherjee (2011)	Reformulate APERC's four 'A's into five dimensions: a. Availability, b. Affordability, c. Technology Development, d. Sustainability, and e. Regulation
Sovacool and Brown (2010)	Energy security has four dimensions: a. Availability, b. Affordability, c. Energy and economic efficiency, and d. Environmental stewardship.
von Hippel, Suzuki, Williams, Savage, and Hayes (2011)	Contains six dimensions.Theydefined energy security as the availability of fuel and energy services to ensure the survival of the nation, the protection of the national welfare and the minimization of risks associated with the

	supply and use of the said services. According to this definition, energy security is composed of six dimensions: a. energy supply, b. economic, c. technological, d. environmental, e. social and cultural, and f. military and security.
Sovacool (2011)	Proposed 20 dimensions of energy security including availability and affordability.
Vivoda (2010)	Built on the work of Von Hippel et al. by adding further 5 dimensions: a. demand management, b. efficiency, c. human security, d. international, and e. policy. Vivoda further deepened the 6 dimensions of Von Hippel et al. by adding 10 “attributes” to them (as well as introducing another 34 attributes with his own five dimensions).
Winzer (2012)	Conceptualization stands apart in that it reflectively mentions but does not directly uses the four As where availability and accessibility are identified with natural and human sources of risks and affordability and acceptability

	with economic and environmental impacts of energy.

Most of the dimensions and objectives are captured in the IEA's, WEC's and APERC's definition of energy security. The IEA omits of accessibility, which can be considered as part of availability based on idea that for an energy flow to be accessible, it must be available. On the other hand, the WECput affordability in the definition of accessibility, while the APERC's lists all of the 4 As. Other studies listed in the Table 2.2 above are generally agreed with those dimensions with some variations or additional elements. The efficiency dimension also becoming more popular as introduced by Vivoda (2010), Sovacool and Brown (2010)and Sovacool (2011) in their studies in recent years. Hence for the purpose of this study, all of those dimensions offered by the above authors can actually be grouped into four dimensions of energy security: availability, efficiency, affordability and acceptability.

2.3. Energy Security Indicators

2.3.1 Simple Indicator

These are common measurements that allow understanding of the results or attributes of the activities performed within an industry's supply chain (OECD, 2008). The single indicators are often linked to measurable outcomes during a specific period. For an indicator to be useful and effective, it has to be relevant to the objectives of the industry. It also has to be clearly defined to ensure the proper collection of information about it. It must be easy to understand and use and be comparable with the performance of similar. The simple indicators are often linked to measurable outcomes during a specific period. Information about single indicators can be found in publicly annual statistical reports or databases. Example of popular simple indicators:

Table 2.3 Simple indicator

Simple Indicator	Example
Energy Intensity	Total Primary Energy Supply/GDP
Energy Dependency	Import/Gross inland energy
Reserves to production ratio	Proven reserve/Primary production
Energy price	Oil price, Gas price, Coal price
Sectoral indicators	Share of biofuel in road transportation (biofuel consumption/petrol consumption)

2.3.2 Diversification Indicator

In an extensive cross-disciplinary review of the literature on measures of diversity, Stirling (1998) identifies three basic properties of diversity:

a. Variety: number of categories into which the quantity in question can be partitioned.
b. Balance: pattern in the apportionment of that quantity across relevant categories.
c. Disparity: nature and degree to which the categories differ from each other.

In the energy field, the Simpson (1949), Shannon and Weaver (1962) and Stirling (2007) diversity indices have so far been applied by authors such as Grubb et al. (2006),Jansen et al., (2004); Stirling (2010).

Table 2.4 Diversification Indicator

Diversification Indicator	Formula	Attributes of Diversity
Simpson Index	$\lambda = \sum_{i=1}^{N} p_i^2$	Variety, balance
Herfindahl-Hirschman Index	$HHI = \sum_{i=1}^{N} p_i^2$	Variety, balance
Shannon-Wienner Index	$SWI = -\sum_{i=1}^{N} p_i log p_i$	Variety, balance
Stirling (quadratic)	$\sum_{i,j=1,i<j}^{N} d_{ij} p_i p_j$	Variety, balance, disparity
Stirling (generalized)	$\sum_{i,j=1,i<j}^{N} (d_{ij})^a (p_i p_j)^b$	Variety, balance, disparity

Source: Skea (2010)

Stirling (1998) identifies a number of effective dual-property measures combining variety and balance, yet finds no metric in the literature that also captures disparity. He concludes that the characterization of disparity is inevitably subjective and ultimately depends on the choice of particular performance criteria. He shown that the Shannon diversity index is the most attractive simple index reflecting both variety and balance in an even way, and inclusion of disparity remains cumbersome.

In case of Indonesia, the energy policy has focused primarily on the availability dimension, where according to Resosudarmo et al. (2010) balance and the variety of energy are the main priorities of Indonesia's energy policy as reflected in the Presidential decree No. 5/2006 on National Energy Policy and Law No. 30/2007 on Energy. Hence for this study, the Shannon index will be used for further elaboration.

2.3.3 Composite Indicator

A composite indicator is formed when individual indicators are compiled into a single index, on the basis of an underlying model of the multi-dimensional concept that is being measured. Table 3.3 below shows of different means of measuring energy security.

Table 2.5 Composite Indicator

Composite Indicators	Method
Supply/Demand (Scheepers et al. 2006)	Based on the structure of the country's energy demand and supply.
The Asia Pacific Energy Research Centre (APERC, 2007)	Uses five indicators of energy security, which measure net import dependency, net oil import dependency, Middle East import dependency, diversity of primary energy types and non-carbon based fuel portfolio (a variation of fuel-type diversity)
Bollen (2008)	Based on willingness to pay.
Gupta (2008), Gnansounou (2008).	Use vulnerability index
IEA (2007), Lefevre (2010), Loschel et al. (2010)	Focus on resource concentration as a driver of longer-term energy security using two indicators: one is for the price component of energy security (competitiveness and volatility), based on diversity of fuel exporters and fuel-types.
Hughes and Shupe (2011)	Employ a decision matrix that ranks a country's sources of energy alternatives according to four criteria.
von Hippel et al. (2011)	Using indicators identified with six aspects of energy security
Jansen et al. (2004), Frondel et al. (2009), Cohen et al. (2011).	Supply risk measurements on diversity of fuel types and import sources.
Costantini et al. (2007)	Grouped indicators of supply security into two categories: dependence and vulnerability

	represented in physical and economic terms calculated based on the Shannon– Weiner diversity index.
de Jong et al. (2007)	Used two quantitative indicators and some qualitative considerations.

Jansen et al. (2004) studied the energy supply security issue in the European Union by constructing four long-term energy security indicators based on the Shannon diversity index applied to eight primary energy supply sources (coal, oil, gas, modern and traditional biofuels, nuclear, renewables and hydropower). The indicators accounted for supply security aspects such as diversi- fication of energy sources in energy supply, diversification of imports with respect to imported energy sources, political stability in import sources, and the resource base in import sources.

Similarly, Costantini et al. (2007) grouped indicators of supply security into two categories: dependence and vulnerability represented in physical and economic terms. The distinction between dependence and vulnerability was made and in their study, the physical dimension of dependence was represented with indicators such as percentage share of net import of oil and gas in total primary energy supply and share of European oil and gas imports in world oil and gas imports while the physical dimension of vulnerability was calculated in terms of degree of supply concentration in trade and production using the Shannon– Weiner diversity index, percentage share of oil used in transportation, and percentage share of electricity produced with gas. In terms of the economic dimension of dependence and vulnerability, the value of oil and gas imports and oil and gas consumption per dollar of GDP respectively, were estimated. These indicators of the European energy system were analysed under different energy scenarios.

In a study by de Jong et al. (2007), a model was developed for reviewing and assessing energy supply security in the European Union, on the basis of pre-agreed criteria. It used two quantitative indicators and some qualitative considerations. The first quantitative indicator is the crisis capability (CC) index.It dealt with the risk of sudden unforeseen short-term supply interruptions and the capability to manage them. The second indicator, the supply/demand (S/D) index covered present and future energy supply and demand balances. Qualitative considerations included multi- lateral measures for securing overall producer/consumer relations and safeguarding vulnerable transport routes for oil and gas.

A number of studies have focused on assessing energy vulnerability. Kendell (1998) explored the meaning and value of measures of import vulnerability as indicators of energy security, in particular, oil security in the United States. While measures of oil import dependence showing the extent of a country's imports may be of interest, they offer a limited indication of energy security. Gupta (2008), APERC (2007), and UNDP (2007) have also examined the relative oil vulnerability of oil-importing countries on the basis of various factors. Using principal component technique, individual indicators such as domestic oil reserves relative to total oil consumption, geopolitical oil risk, oil intensity, cost of oil in national income and ratio of oil consumption in total primary energy consumption were combined into a composite index of oil vulnerability. Percebois (2007) clarified the distinction between vulnerability and energy dependence and presented a coherent set of indicators including import concentration, level of energy import value in output, risk of blackout in the electricity sector, price volatility, exchange rates, and industrial and technological factors that are used to analyse energy vulnerability. Gnansounou (2008) defined a composite index of energy demand/ supply weaknesses as a proxy of energy vulnerability. The index is based on several indicators such as energy intensity, oil and gas import dependency, CO2 content of primary energy supply, electricity supply weaknesses and non-diversity in transport fuels. The assessment of the composite index was applied on selected industrialised countries. In 2008, the World EnergyCouncil (2008) identified threats to the European economy which could lead to potential energy crises and suggested solutions for facing related key challenges. The study also developed a number of indicators to assess the level of different types of vulnerability, as well as the overall vulnerability of a country or region, including threats to physical disruption and higher energy prices.

The design of a composite index of energy security has been undertaken in previous studies. A composite vulnerability index was developed by the World Energy Council (2008) to benchmark and monitor European countries' respective efforts to cope with long-term energy vulnerability. Similarly, de Jong et al. (2007) designed state-of-the-art indexes of energy security risk (i.e., the crisis capability index and supply/demand index) which are oriented towards a comprehensive and analytical representation of the energy supply chain. However, the shortcoming of these approaches was the use of subjective-opinion-dominated weighting systems and scoring rules where the weights and the rules were based on expert judgements. In response to this shortcoming, Gnansounou (2008) proposed an alternative method which was objective-value-oriented and statistics-based. Gnansounou defined the composite index as the Euclidean distance to the best energy security case represented by the zero point. The Euclidean distance is standardised in order to get a value between 0 and 1.

There are more comprehensive methods developed by institutions in the developed countries (DECC, 2011; Institute for 21st Century Energy, 2010; METI, 2010). However, these are unsuitable for application to Indonesia as they require data, which are not regularly published or even collected, or they are of limited value for assessing the energy security of Indonesia. For example, technological development indicator, which based on expenditures on research and development of energy technologies, is not suited because Indonesia is technology adopter country rather than technology developers. Therefore, inclusion of such issues needs careful consideration. As such, there is a requirement to refine the available tools to suit the needs and limitations of Indonesia. This will be further discussed in energy security dimensions conception in the chapter 4.

3. Overview and Preliminary Analysis of Indonesia Energy Security

3.1. Introduction

Indonesia is an archipelagic country with approximately 17,000 islands in a total area of 1,904,569 km^2, the 15^{th} largest in the world. Of this total area, 1,811,569 km^2 is covered by land and 93,000 km^2 is covered by water. By 2013, population of Indonesia has reached 249.87 million, which made Indonesia the fourth most populous country in the world. Currently Indonesian GDP is 10^{th} largest in the world, with the GDP per capita (current US$) in 2013 of US$ 3475. Indonesia's average economic growth for the period of 1980-2013 was 5.5% per year.

The Indonesian government has placed energy security as one of its policy priorities. The Indonesian Ministry of Energyand Mineral Resources states that one of its missions is to provide energy security and ensure energy independence as well as increase energy's value added that takes into account environmental issues and present the greatest benefit to the welfare of the people. Article 3 in the law on energy (Law No. 30/2007) states that the ethos behind managing energy in the country is to support the country's national sustainable development and energy security. However the law does not exactly define energy security. The law does mention the goals of managing energy, which are as follows:

a. Achieving independent energy management;

b. Guaranteeing the availability of energy in the country, both through domestic and foreign sources;

c. The availability mentioned above is for:

   1. Supplying domestic energy demand;

   2. Supplying intermediate inputs of domestic industries;

   3. Increasing foreign reserves;

d. Guaranteeing optimal, integrated, and sustainable management of energy resources;

e. Efficient use of energy in all sectors;

f. Improving energy access for low income people and those living in remote areas to improve their welfare in an equal and just way by:

   1. Providing support to make energy available to people on low

incomes;

2. Building energy infrastructure in undeveloped regions, so reducing regional disparity;

g. Developing autonomous energy industries and services and improving human professionalism; and

h. Protecting the environment.

Based on these goals of energy management stated in the Law No. 30/2007, most Indonesian policy makers and energy analysts talk in terms of the 4 As (availability, accessibility, affordability, and acceptability); meaning the availability of energy at all times in various forms, in sufficient quantities, that can be accessible by most people at affordable prices, and obtained in a way that is not environmentally destructive.

Along with the rapid economic growth, Indonesia’s energy consumption increases. Masih and Masih (1996), analyses the relationship of energy consumption and economic growth of Indonesia from 1955 to 1990. Other related studies on the relationship between energy consumption and economic growth of Indonesia by Hwang and Yoo (2014) and Soares et. al (2014) also indicate the presence of a strong statistical relationship between GDP and energy consumption in Indonesia. Using data from BP 2014 and WB (2014), Fig. 3.1 shows parallel trend of GDP and energy consumption between 1980 and 2013.

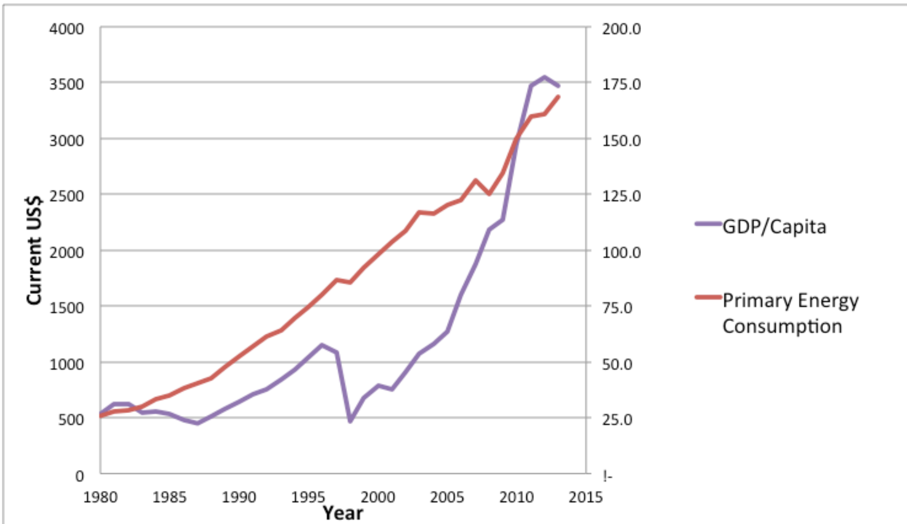

Figure 3.1 Energy Consumption and GDP Per Capita

Despite high amount of total primary energy consumption i.e. 168.7 MTOE (WB, 2014) (ranks 15th in the world) and high average growth of primary energy supply in the past four decades i.e. 7.7% per year (Ibrahim et.al, 2010), the primary energy consumption of Indonesia in 2013 is still relatively low at 0.67 TOE per capita, compared to the word’s average, 1.7 TOE (BP, 2014). With the rapid economic growth, urbanization and industrialization, it is expected that the primary energy consumption will keep increasing in the future.

Total primary energy supply increased steadily, where it reached 1537.6 MBOE in 2012, which is more than 150% increase from 2000’s level. However, the new and renewable energy resources (NRE) utilization is still limited due to high production cost and the subsidy policy on fossil energy. Non-renewable energy resources such as oil, gas and coal have always been dominated the primary energy supply. Table 3.1 shows the share of the primary energy supply by source from 2000 to 2012 (MEMR, 2014a). The contribution of crude oil in energy supply in Indonesia has decreased from 43.52% in 2000 to 39.15% in 2012. On the other hand, the contribution of coal in energy supply increased sharply from 9.42% in 2000 to 22.44% in 2012, which is mainly demanded by power generations and the cement industries. With increasing environmental issues, the use of natural gas also is expected to grow at a steadily increasing pace. The contribution of renewable energy resources such as hydropower and geothermal is relatively small, by only 3.18% in 2012.

Table 3.1 Primary Energy Supply Share

Primary Energy Supply	Amount (MMBOE)			Share (%)		
	2000	2006	2012	2000	2006	2012
Coal	93.83	205.78	345	9.42	17.51	22.44
Crude Oil	433.36	461.35	602.01	43.52	39.25	39.15
Natural Gas	164.65	196.60	259.46	16.54	16.72	16.87
Hydropower	25.25	24.26	32.23	2.54	2.06	2.10
Geothermal	9.60	11.18	16.57	0.96	0.95	1.08
Biomass	269.05	276.34	282.34	27.02	23.51	18.36

Similar to the primary energy consumption, the final energy consumption also shows an increasing trend. Fig. 3.3 shows the final energy consumption by sector in Indonesia from 2000 to 2012 (MEMR, 2014). Industrial, household and transportation sectors are the three biggest final energy consumers. In 2012, they occupy 29.91% (347.14 MBOE), 28.52% (331.06 MBOE) and 26.76% (310.62 MBOE) of total final energy consumption (1160.6 MBOE). However, energy access is still limited, for example in 2012, approximately 23.4% of the population has no access to electricity (MEMR, 2014).

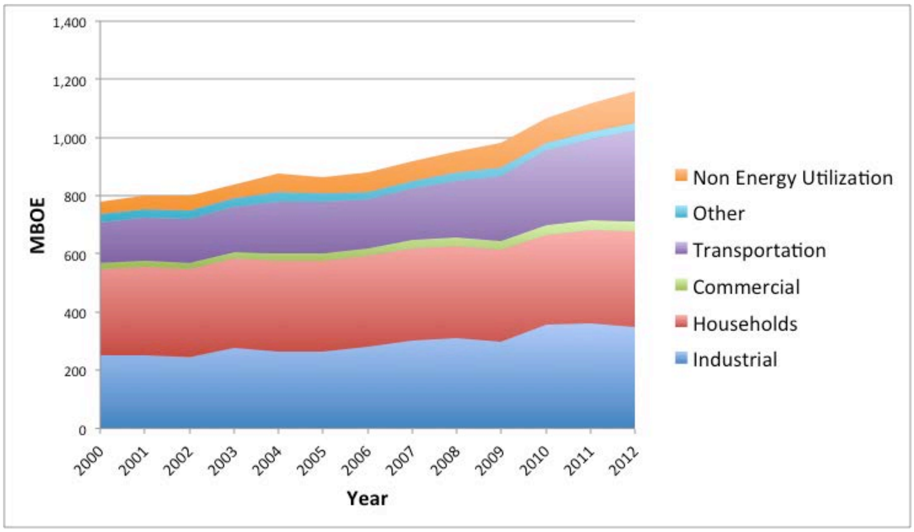

Figure 3.2 Final energy consumption by sector

The dependency of Indonesian energy scenario to fossil fuels will have an adverse effect on the economy in Indonesia. The fact that fossil fuel is exhaustible resources, increasing greenhouse gas emission from burning fossil fuels will increase risk toward security of energy supply. Indonesia's status change from oil net-exporter to oil net-importer country in 2003 has increased Indonesia's concern over energy security. Furthermore, low utilization of new and renewable energy resources will also increase the risk on securing energy supply. Therefore, action toward using renewable energy source should be put as priority by the government.

Currently gas and coal are exported to support the economy.

About 35% of national annual budget is coming from energy export income. According to Ibrahim et. al (2010), to allow Indonesia to shift its economy from natural resources and agriculture base into industrial and agriculture base, it is estimated that up to 2050, the economic growth should be more than 6% per year while the population will grow to be around 307 million people by 2050. This means, security of energy supply will become more important task for the government in the future.

The government of Indonesian tries to cope with this situation by setting energy mix target by 2025. The Regulation No. 5/2006 targeting the 2025 energy mix constitutes of 20% oil, 30% gas, 33% coal and 17% renewable resources. Challenges like increasing the availability of renewable energy resources, establishing grids of energy supply under difficult transport conditions as well as fostering consumption of renewable energy sources.

This qualitative chapter presents a current overview of energy supply resources. The paper is structured as follows: section 1 provides introduction to Indonesia's growing energy demand and the needs of a secure energy supply. Section 2 presents Indonesia's energy security overview in terms of resources, reserves, productions. Section 3 describes energy scenario and outlook, section 4 provides analysis and followed by conclusions and policy implications in section 5.

3.2. Energy Reserves, Resources and Productions

3.2.1. Oil

Indonesia is the 24th largest crude oil producer in the world in 2013, accounting for about 1% of world production (EIA, 2014). Oil has become an important part of Indonesia's economy since it was first discovered in 1885 in northern Sumatra. Declining oil production and rising domestic demand resulted in Indonesia suspended its membership in OPEC in 2009, after joining in 1962. Indonesia currently imports crude oil and refined products to meet demand. Fig. 3.3 shows Indonesia’s oil production and consumption from 1990-2013 (BP, 2014). According to Indonesia Energy Outlook (MEMR, 2013b), oil demand is projected to rise from 1.6 mb/d in 2012 to 3.6 mb/d in 2035, while its share of the energy mix fell from 42.2% in 2012 to 26.5% in 2035.

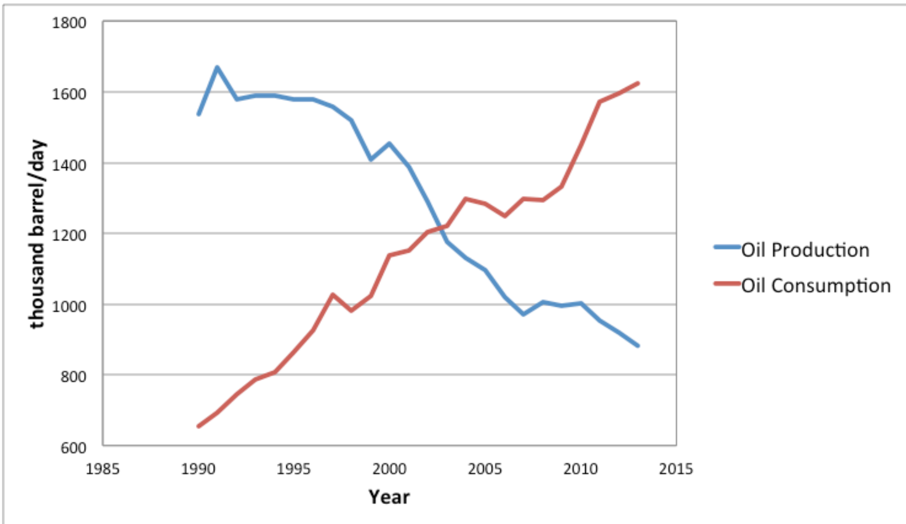

Figure 3.3 Oil production and consumption 1990-2013

Indonesia's proven crude oil reserves were 3.74 billion barrels at the end of 2013, down from 4.23 billion barrels at the end of 2010 (ESDM, 2014). The reserve to production ratio in 2012 is 11 years, which means with the current year's level of production, the reserve will be depleted in 11 years. In 2013, the volume of reserves obtained from the 2013 approved plan of developments is less compared to production, resulting in a 73.46% Reserves Replacement Ratio (RRR), which is below the target (SKKMigas, 2014). This is due to the declining investment in oil exploration, especially in deep-water blocks. Petroleum and other liquids (or total liquid fuels) production declined from a high of nearly 1.7 million barrels per day (bbl/d) in 1991 to

882,000 bbl/d in 2013 (BP, 2014). Crude oil and lease condensate production made up 834,000 bbl/d of this total, a level below the government's original 2013 target of 900,000 bbl/d. The total number of new exploration and development wells increased to 1052 in 2013, increasing by 212 from 2012, according to SKKMigas (2014).

The government's annual crude oil production target, which has been overstated each year since 2009, is 870,000 bbl/d in 2014, although Indonesia reported that it plans to reduce this target to 820,000 bbl/d. The decline rate of oil production in 2013 was 3.7%; this number is lower than the previous year at 4.5%. Several factors put downward pressure on Indonesia's oil output each year, including: licensing approvals at the regional level of government, land acquisition and permit issues, oil theft in the South Sumatra region, aging oil fields and infrastructure, and insufficient investment in unexplored reserves.

3.2.2 Gas

Natural gas production has increased by more than 60% between 1990 and 2013. While Indonesia still exports about half of its natural gas production, domestic consumption is increasing in tandem with production. Fig. 2.5 shows Indonesia’s gas production and consumption from 1990-2013 (BP, 2014).

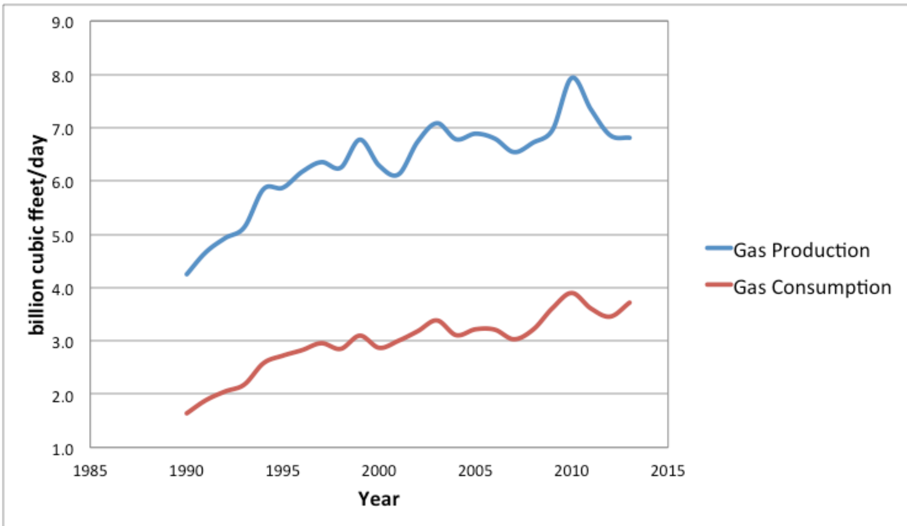

Figure 3.4 Gas production and consumption 1990-2013

Indonesia's proven natural gas reserves by the end of 2013 are 103.35 trillion cubic feet (Tcf), down from 108.4 Tcf in 2010 (BP, 2014). Currently the reserve to production ratio (R/P) is 41 years. The country ranks as the 13th largest holder of proven natural gas reserves in the world, and the second largest in the Asia-Pacific region, after China. The country continues to be a major exporter of pipeline and liquefied natural gas (LNG). At the same time, domestic demand for natural gas has doubled since 2005. Natural gas shortages caused by production problems and rising consumption forced Indonesia to buy spot cargoes of LNG to meet export obligations in recent years. According to MEMR (2013b), natural gas demand is projected to grow almost five times from 1.4 bcf in 2012 to 6.8 bcf in 2035, with average annual growth of 6.9%.

The government began constructing new LNG receiving terminals and gas transmission pipelines to address domestic gas needs, although this is likely to reduce the natural gas available for export. In 2008, 52.2% of natural gas was exported to Japan, South Korea and Taiwan. However, Indonesia now faces increased competition from Qatar and Malaysia. Production from blocks such as Tangguh in Papua and Cepu block in Central Java are designed to give a boost to the country's natural gas production. The Bintuni Bay, located in West Papua, and the Central Sulawesi region are emerging as new important offshore gas resource areas.

In recent years, some companies have shifted their attention toward less-explored parts of the country. Pertamina, PetroChina, and ConocoPhillips are key producers in the Natuna Basin within the South China Sea. These companies produced about 200 Bcf of gas from the basin in 2011. As of the beginning of 2014, the partners have not reached a finalized PSC for the Natuna D Alpha block in the eastern section of the basin. The block is technically challenging to develop as a result of its large carbon dioxide concentrations, but it contains a sizeable 46 Tcf of proven reserves.

Increasing domestic demand continues to reduce Indonesia's capacity for exports, and the country might not be able to meet its external obligations. Moreover, Indonesia's geography presents a challenge to resource development and makes the switch to natural gas for domestic consumption more difficult. The nation's most prolific blocks of gas reserves are located far from its major demand markets, and regulatory uncertainty delays investment needed for exploration. Foreign upstream investment in PSC areas fell in 2012.

Indonesia's government promotes exploration of coal bed methane (CBM) and shale gas, alongside conventional crude oil and natural gas projects. The Ministry of Energy and Mineral Resources estimates that the country has CBM reserves of 453 Tcf based on preliminary studies. In 2007, the Indonesian government started awarding CBM blocks in the South and Central Sumatra basins on Sumatra Island and the Kutei and Barito basins in East Kalimantan. The government anticipates CBM production to reach 183 Bcf/y by 2020.

There is currently no shale gas production in Indonesia, but policy makers are interested in exploring the country's shale oil and shale gas potential. In April 2012, the Indonesian government initiated four shale gas study projects and expects commercial shale gas production to begin by 2018. As of December 2013, Indonesia has awarded only two shale gas PSCs for the Sumbagut block in North Sumatra, both to Pertamina. The Sumbagut block is estimated to contain about 19 Tcf of potential shale gas resources. MEMR estimates that Indonesia possesses 574 Tcf of shale gas resources potential (Gautama, 2014). A major challenge to the growth of the shale industry is the cost of exploration in Indonesia, estimated to be as much as four times the drilling cost in North America because the deposits are far from demand centers and infrastructure needed to transport the gas.

3.2.2 Coal

Coal is Indonesia’s largest fossil energy resource. Indonesia plays an important role in world coal markets, particularly as a regional supplier to Asian markets. It has been the largest exporter of thermal coal, typically used in power plants, for several years. Indonesian is the 4^{th} largest coal producer in the world; in 2013 it amounted to 421 MT and 6.7% of global production (BP Statistical review of world energy, 2014). Currently, Indonesia is the world's largest exporter of thermal coal, with roughly 75% of production leaving the country. Indonesia's coal exports serve primarily Asian markets, with about 70% of total exports being sent to China, Japan, South Korea, India, Taiwan, and other Asian markets. Domestic coal demand is projected to rise by 5.5% over the outlook period, to 279 Mtce, pushing its share of Indonesia’s primary energy demand up to 23.6% in 2035 (MEMR, 2013b).

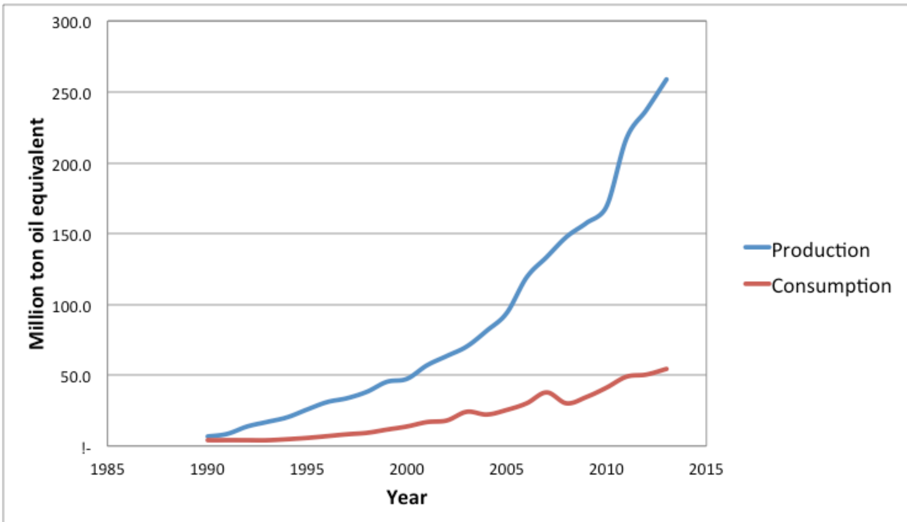

Figure 3.5 Coal production and consumption 1990-2013

Intensive exploration conducted both by government and industry, estimates Indonesia’s coal resource is estimated around 161.48 billion ton. Where 120.52 billion ton comes from open pit mining and the rest 40.95 billion ton is considered as deep seated coal. Coal reserve is 31.35 billion ton, proven reserve is 8.90 billion ton and 22.46 billion ton is categorized as probable reserve. Reserve to production ratio in 2012 is 75 years.

Kalimantan is home to 53 % of coal reserve and produce 90% of national production. Sumatra possesses 46% of national coal reserves and produce only 10% of national capacity. Indonesian coal is primarily bituminous or sub bituminous in rank, and the country produces a small amount of lignite used by the power sector.

Coal production quadrupled between 2002 and 2012, reaching 452 million short tons. Supply growth slowed to 9% in 2012, its lowest level since 2008 as a result of low international coal prices. Approximately two-thirds of Indonesia's coal production comes from East Kalimantan, according to industry estimates.

Indonesia's coal consumption grew to 76 million short tons in 2012. The electricity sector is the largest source of domestic coal consumption. Power plants accounted for nearly two-thirds of total coal sales in 2010. Demand for coal from electricity sector is expected to increase in the next few years as a result of increasing number of coal-fired generation capacity constructions.

Although coal consumption has been growing significantly in the past decade, coal is still more to commodity than energy resource where the majority of production, almost 80%,still gone for export. However, in the recent years, Indonesia's government encourages increased use of coal in the power sector, due to the relatively abundant domestic supply. Coal use also to reduceexpensive diesel and fuel oil consumption in power generation sector. The government’s first Fast Track programin 2004 includes the construction of 10,000 MW coal-fired power plants. Despite the efforts to diversify the energy mix and prioritise renewable energy as part of the second Fast Track Program, coal is still dominant.

In January 2011, the Ministry of Energy and Mineral Resources announced a ban on exports of coal with a calorific value below 5400cal/gram by 2014, in order to conserve reserves as well as to push producers to upgrade the heating value before exporting.In order to guarantee sufficient domestic supply, the Indonesian government set a DMO of 24% for producers. This DMOwas temporarily revised down to 20% in October 2012 as a result of lower than expected consumption.

3.2.3. Geothermal

Indonesia is located between the eastern end of Mediterranean Volcanic Belt and western side of Circum Pacific Volcanic Belt. The Circum Pacific Volcanic Belt or known as The Ring of Fire is associated with a nearly continuous series of oceanic trenches, volcanic arcs, and volcanic belts and/or plate movements. It has 452 volcanoes and is home to over 75% of the world's active and dormant volcanoes, where more than 200 volcanoes are located along Sumatra, Java, Bali and the islands of eastern part of Indonesia. This geological position has made Indonesia holds tremendous geothermal power potential, estimated 40% of world’s geothermal energy reserves (Darma et.al., 2010).

Directorate General of New and Renewable Energy and Energy Conservation (DGNREEC, 2012) estimate that Indonesia’s geothermal potential is approximately 29.038 MW of electricity. The Government of Indonesia has established ambitious targets for geothermal power development as a leading alternative energy to substitute fossil fuels and might be fulfilling Indonesia’s growing demand for electric power, as stipulated in Presidential Decree No. 5/2006 on National Energy Policy. According to this Presidential Decree, geothermal power is projected to reach 5% share of national energy mix in 2025, or equivalent to 9500 MW.

However, progress in this sector has been slow. Current installed capacity is only 1,341 MW, or around 4.62 percent of its potential (MEMR, 2014a) compared to its potential. The tender process for geothermal working areas (in Indonesian: wilayah kerja pertambangan panas bumi, WKP), which builds upon the Geothermal Law (Law No. 27/2003) and associated implementing regulations, has revealed various impediments to rapid expansion of geothermal power capacity. In general there are four kinds of impediments of geothermal development in Indonesia, i.e. incremental cost of generating power using geothermal compared to fossil fuel i.e. coal, availability of development inputs, pricing and non-price geothermal policy.

While the basic principles of Law No. 27/2003 remain sound (openness to private participation, the use of competitive tendering, and the active role of regional government), it has become clear that the Indonesia’s geothermal power policy must be reviewed and revitalized if the Government is going to realize the potential of geothermal power.

3.2.4 Hydropower

Hydropower potential is about 75.670 MW, with installed capacity of 4.033,5 MW or only 5,6 % of its potential (MEMR, 2014b). Of the current installed capacity for all hydropower plants, small units contribute about 462 MW. The largest hydropower resources are located in Papua from the Memberamo river with estimated resources of 10,000 MW (MEMR). The hydropower plants comprise micro, mini, small and large units, with a significant portfolio of small hydro power projects planned or under construction.

3.2.5. Solar and Photovoltaic Energy

Indonesia’s solar resource potential is very significant due to its geographical location. Installed capacity is 13.92MWp in 2012 increased by more than eleven times compared to 2005. Installing photovoltaic energy is relatively expensive compared to non-renewable energy, and the technology requires intensive maintenance, which is a problem on small islands or in remote areas. The primary weakness in the Indonesian solar industry is the lack of local manufacturing facilities for high quality batteries and PV modules, though the government actively supports the development of solar PV applications.

3.2.6. Biomass

Indonesia has a large potential of biomass energy, which traditionally has been used through direct burning and later on through modern conversion technology such as pyrolysis and gasification. Energy potential from biomass is approximately 35.6 GW, from rice husk (19,1 GW); corn (3,47 GW); cassava (2,3 GW); palm oil (0,81 GW); coconut (0,82) and production forest (8,8 GW). Geographically, Java island has the highest potential (from rice husk), followed by Kalimantan (production forest waste).

The main source of biomass energy in Indonesia could be rice residues with a technical energy potential of 150GJ/year. Yet rice residues produced by rice mills have low bulk densityand cause high transport costs, so the economically viable potential has to be considered. Other biomass resources are forest or plantation residues (e.g. rubberwood, coconut residues), agricultural residues (e.g. sugarmill residues, palm oil residues) and municipal waste. By 2012, on grid installed capacity from biomass is 75.5 MW.

3.2.7. Ocean and Wind Energy

Ocean energy has not been intensively developed on a commercial scale. The Agency for Assessment and Application of Technologies (BPPT) examined more than15l locations and indicated the potential for tidal wave energy; three locations are candidates for ocean thermal conversion development. At present, Indonesia’s wave power capacity reaches 6 GW (Wahyuni,2011).

Due to the lack of wind along the equator, wind energy potential is very limited. The windiest area tends to be on the less populated islands in the country. Therefore wind energy development concentrates on small or medium size projects mainly for rural electricity supply, water pumping and battery charging.

3.3. Energy Scenario and Outlook

Indonesia's population is currently 238 million, with a growth rate of 1.9% in 2010, and is expected to grow to around 265 million by 2020 and 306 million by 2050. Domestic energy consumption is predicted to increase by three fold from 2010 to 2030. Traditional energy production utilizing almost exclusively non-renewable resources cannot keep pace with this growth. As an effort to secure sufficient future energy supply, the Government released the Presidential Regulation No. 5/2006 on National Energy Policy. This Regulation defines targets, policies and actions for their implementation.

3.3.1 Targets

Article 2 of Regulation No. 5/2006 defines two targets, namely the achievement of energy elasticity of less than 1 in 2005, and secondly the creation of an energy mix optimally in 2025 with diminished portions of oil, gas and coal and increased portions of new and renewable energy in domestic consumption. Oil shall become less than 20%, gas less than 30%, coal less than 33%; while biofuel and geothermal shall each become more than 5%; other “new energy” and renewable energy, particularly biomass, nuclear, hydropower, solar power, and wind power shall become more than 5%, liquefied coal more than 2%.

The target of Indonesian energy policy is to apply an optimum energy mix comprising all viable prospective energy sources. The amount of domestic energy consumption is assumed to rise threefold by 2025. The 5% portion of non-fossil energy in 2005 is scheduled to increase to 15% in 2025.

The targets set out in Article 2 of the Presidential Regulation No. 5/2006 are to be achieved through both the main policy and a supporting policy (Article3). The main policy consists of:

a. Assurance of availability of domestic energy supply, optimization of energy production and realization of energy conversion;
b. Energy exploitation efficiency and energy diversification in order to reduce dependence on oil by expanding the use of coal, gas, renewable energy resources and new energy resources such as nuclear, oil shale and coal bed methane;
c. Stipulation of the economic energy price taking into consideration the ability of small enterprises and aid to the poor within a certain period. At present, energy subsidization has become a large burden for the state budget, has lead to increasing reliance on imported energy and is a serious deterrent to investment in energy efficiency, new infrastructure for electricity and development of Indonesia's remaining significant oil and gas resources.
d. Environmental conservation by application of sustainable development principles. The Indonesian Government has made a commitment to reduce emissions by 26% within 2020 as explained

by the President at the G-20 Forum in Pittsburgh, USA, I in 2009. The “low carbon society” should be realized as a strategy toward significant emission reduction (Thavasi & Ramakrishna, 2009).

3.3.2 Policy Actions

The Minister of Energy and Mineral Resources issued the National Energy Management Blueprint (cp. Article 4 of the Regulation No. 5/2006). It focuses on a policy regarding the assurance of sufficiency of domestic energy supply and provides a public service obligation policy. Management of energy sources shall become the foundation for an arrangement of policy for development and exploitation of each kind of energy. Moreover, the National Energy Management Blue print includes programs to phase out subsidies and road maps for each alternative energy sector. The general subsidies of the past are to be replaced with more targeted incentive programs to achieve social objectives and encourage diversification. In 2006 the Government devised the first Fast-Track program for the construction of 10,000MW of coal-based power generation plants by PLN, which was viewed as the only readily available solution for utilizing domestic coal resources to displace high-cost generation units (fuel fired power plant) in an affordable manner. This decision, along with existing heavy use of diesel, will further increase the country's dependence on fossil fuels.

3.3.3 Energy Outlook

In 2013 MEMR published the latest edition of its Indonesia Energy Outlook. The energy outlook uses three different scenarios to describe energy situation from 2012 to 2035, Business As Usual (BAU) scenario, Alternative Policy (ALT) scenario, and Gas Coal optimization scenario. BAU scenario is take base on recent government policy that had been applied before 2012 and assumed not change during the outlook period. ALT scenario is base on government policies are recently announced including those that are yet to be implemented or is planned to be implemented. Gas Coal optimization scenario is developed as policy simulation scenario rather than being a projection based on a historical trend, it simulate natural gas and coal export limitation to meet long term energy security goal to guarantee the availability of domestic energy.

According to the ALT scenario, fossil fuels continue to dominate Indonesia's primary energy mix, accounting for 75% of primary energy use in 2035 compared to 81% in 2012. Oil demand rises from 1.6 mb/d in 2012 to 3.6 mb/d in 2035, while its share of the energy mix represent down from 42.2% in 2012 to 26.5% in 2035. Natural gas demand grows almost five times from 1.4 bcf in 2012 to 6.8 bcf in 2035, with average annual growth of 6.9%. Coal demand is projected to rise by 5.5% over the outlook period, to 279 Mtce, pushing its share of Indonesia's primary energy demand up to 23.6% in 2035. In 2035, the share of renewables reaches 25% of the primary energy mix, from 19% in 2012. Total final energy consumption rises at a projected 5.5% per year on average through to 2035. Final energy use in industry grows faster than other end use sector, rising by an overall 7.3% in 2012-2035. Energy Consumption in transport is projected to increase at an average rate 5.9% per year in 2012-2035, driven by rising demand for mobility.

3.4. Analysis

Indonesia's primary energy supply relies heavily (almost 80%) on fossil fuels and the remainder on geothermal and hydropower and biomass. By2025, the dependency on fossil energy is to be reduced significantly while renewable and alternative forms of energy are to grow to 17% of the total. This target of energy mix, particularly in reducing oil consumption, is a great challenge. Huge investments and infrastructure will be required to develop other source of energy i.e. geothermal, hydropower and coal bed methane. On the other hand, priority in energy production has to focus more on domestic needs to meet the growing domestic demand for energy. This is reflected in the Law on Mineral and Coal Mining of 2009 and the Law on Petroleum and Natural Gas, which obliged local companies to sell a considerable portion of their respective production to the local market. Consequently, domestic utilization is more and more constraining the amount available for export. For example, electricity generation has shifted from oil to coal and aims to finally place more weight on renewable resources, mainly geothermal energy.

Significant problems for energy supply are high transport costs between the islands and primary energy production centers, insufficient capacity of the existing energy infrastructure such as coal terminals, electricity transmission network, gas distribution pipelines and energy storage capacity. Exploration for oil and gas as well as geothermal has been slow in the last few years as a consequence of the low investment in the sectors. Energy companies face regulatory hurdles, stalled coordination between ministries and local government, difficulties in land acquisition while land prices continue to increase.

The gap between declining domestic oil production and increasing consumption is growing, this implies the need for oil imports. Indonesia has issued policy to reduce import dependency by offering incentives to encourage greater private investment in exploration. Domestic gas demand will increase due to the government policy on substituting kerosene with gas for household, transport and industrial use, responding to falling oil production. Major investment in logistic infrastructure is required, as more than 70 of Indonesia's gas fields are located offshore, in areas far from the electricity grid network and the main population centers. The Indonesia Economic Corridors Master Plan to 2025 aims to position refineries and industrial production sites at the sources of primary energy production. The state oil and gas company, Pertamina, is aiming to reduce imports dependence by expanding existing facilities and construction of new refineries to double current production.

The investment climate has to be improved to incentivize investors and guarantee cost recovery for exploring new blocks. Renewed focus has been placed on production and exploration. Ministerial Regulation No.6/2010 introduced a 5% tax on transfers of contracts during the exploratory stage thereby penalizing companies trying to share the risk. An improvement in the investment climate that has already been made was the introduction of direct bidding as opposed to tendering blocks and the increase in production splits for companies to 25% for oil and 40% for gas.

The Government of Indonesia has been expanding domestic use of coal for electricity generation in the last decade. An increase of coal production will require intensive investment in exploration and improvement of transport infrastructure, further more clarification of the implementation of the new coal and mining law, particularly concerning the domestic supply obligation.

Indonesia seeks to capitalize on its vast reserves of coalbed methane for electricity generation in order to realize its goals to be a low cost, low carbon economy. Highly prospective are as that have attracted international CBM companies are situated in South and Central Sumatra and East Kalimantan. The production targets are set at 2000 MW of powerby 2015. However, infrastructure for distribution has yet to be improved. The necessary legal framework has to be developed, considering the environmental impact of CBM extraction.

The roadmap for renewable energy created by the Ministry of Energy and Mineral Resources states policy actions for giving incentives for renewable energy development, spreading knowledge to the rural communities as the end-users, and monitoring and evaluation of the actions taken. Implementation programs to speed up utilization of renewable resources focus particularly on geothermal energy, hydropower and biogas.

The geothermal sector has so far developed less than 5% of reserves, although there is great interest from investors. Overlapping government regulations cause uncertainties, lack of knowledge among local authorities and the need of a Power Purchasing Agreement with PLN that determines the commercial viability of a project, form obstacles. Under the Geothermal Law of 2003, geothermal concession tenders are done at a national level, while the local governments are responsible for issuing the licenses, but in many cases do not have the expertise to gather the data on potential sites and to administer tenders effectively. Around 80% of potential sites are in conserved forest (Ministry of Industry, 2011), where open mining is prohibited by the Forestry Law No.39/2004. This law has been a major hindrance to the development of geothermal exploration. A Presidential Decree in February 2010 has derived from this law and permitted geothermal mining and powerplants of strategic importance in areas of protected forest to encourage investment into the sector. Exploration costs are extremely high, the capital expenditure for a geothermal project is far higher than a gas or coal fired power plant. The pricing of electricity and the abolition of subsidies, as announced by 2014–2015, will therefore be a critical factor in the further development of geothermal energy.

Indonesia has so far utilized less than 6% of its hydropower capacity. Although the Electrical Supply Business Power Plan aims to have 5140 MW of hydropowered electricity on stream by 2019, there were only three large scale projects being executed at the end of 2010. The varied sizes and lack of experience has led to most projects not making it past the pre-feasibility study. Bureaucracy regarding contradictions of land ownership around river areas between central and regional government is a further obstacle. The remote location of sources makes the connection to the electricity grid also a difficult task.

The conflict of land use for food or for biofuel production, and the environmental impact through deforestation and loss of biodiversity cannot be neglected. Regulation is required to reduce the negative impacts of large-scale production, as well as to ensure that the most effective technologies are used. The Government to boost alternative energy industries, including biofuels produced from palm oil and jatropha oil, to reduce the need for liquid fuel like gasoline and diesel oil. In an effort to reduce fuel consumption and to support green economy movement, the Indonesian government need to further limit subsidized fuel and to encourage people to switch to gas consumption.

Presidential Regulation No.5/2006 explicitly names nuclear energy as a target of national energy policy. Nuclear activity in Indonesia began in the 1950s with the establishment of the State Committee for the Investigation of Radioactivity, the Atomic Energy Council and the Atomic Energy Institute. By1987, several nuclear research and development and engineering facilities were built. In cooperation with the International Atomic Energy Agency (IAEA) and friendly states like USA, France and Italy feasibility studies and evaluation of sites for nuclear power plants were performed. In 2002, a new long-term study on electricity generation identified nuclear power as “the third principal generation option behind gas and coal”. In line with Law No.17/2007 on the Long-term National Development Plan 2005–2025, nuclear electricity generation should commence operation 2015–2019. A regulatory framework for financing, human resources development, licensing, waste management and future NPP decommissioning was to be established in collaboration with foreign experts and the IAEA (IEA, 2008). Currently, Indonesia operates three research reactors and has determined two possible locations for a NPP. Uranium mines in Kalimantan and Borneo could supply the nuclear fuel, additional imports from friendly nations are taken into account if necessary. After the shock of the Fukushima catastrophe of February 2011, Indonesia continues its plans to build the country’s first NPP. Within the presidential advisory board, the National Energy Council, opinions are split. Some say that Indonesia with its hundreds of volcanoes is earthquake prone and should not proceed with its nuclear plans; others are convinced that modern technology can cope with these risks, and that high energy demand in the long term nuclear power plant become a better alternative source of energy.

3.5. Conclusions and Policy Implications

Indonesia’s energy need grows along with its economic growth. Conventional oil, although depleting, will remain an important energy source. In 2012 the R/P ratio will only extend for 11 years. However if the recoverable resources become available, the R/P ratio will be increased. In addition, there is a significant non-conventional oil resource base, which could become part of the reserves base in the future.

Indonesia energy consumption still depends on non-renewable energy such as crude oil, coal and natural gas as a source of energy. Even though Indonesia has huge amount of energy source which most of it coming from oil, coal and natural gas, cannot be helped it will be run out someday. In addition, utilization of fossil fuel continuously contributes huge amount of greenhouse gases emission andcan lead to climate change. Considering the depletion of fossil fuel reserves and adverse of greenhouse gas emission, using sustainable and renewable energy is unavoidable.

Natural gas is more reliable than oil in terms of availability because gas resources have notbeen developed to the same extent as oil resources and they are more widely distributed. Non conventional gas resources are also abundant.

Estimated coal reserves are large where the R/P ratio is 75 year and therefore are expected to serve domestic needs well throughout this century.

Although the country has applied and extends utilization of renewable energy, the contribution of renewable energy in power generation is only around3%. Considering Indonesia’s natural condition and geography, itis blessed with great potential of renewable energy such as solar energy, wind energy, micro hydro and biomass energies. Noting the potential of this country in using renewable and sustainable energy resources, the government must pay more attention to the renewable energy utilization. Many efforts have been done to promote renewable energy such as by developing energy policy and regulations, yet it still did not give any result. Government, non-government agencies and the public should take more proactive steps to promote and use renewable energy in order to achieve sustainable energy.

The NRE and hydro energy resource base is sufficient to cover the current primary energy consumption despite its specific physical constraints, such as weather dependence and low energy supply density. For example, solar/wind power plants have 1/500 the power generation density per square meter of fossil fuel/ nuclear power plants and 1/100 of hydro power plants. Therefore, NRE and hydro energy are affordable on a local scale, but not as a major energy supply resource.

Similar to NRE and biofuels have supply capacity constraints; therefore, their potential role as a substitute for conventional fuels is limited. Nevertheless, its importance is growing as a result of energy supply security concerns. Further technology development will help reduce these limitations in the future.

4. Essay 1: Energy Security Evaluation Using Index Method

4.1. Introduction

In this chapter, we develop a tool to quantitatively assess energy security that is practical for application to the case of Indonesia. Utilizing a mixed methods approach based on available literature review, the tool consists of a set of indicators that cover the core aspects of energy security. Further, the tool should be practical for application on an annual basis so as to allow trending of results over time.

Hence there is a need to identify the core aspects and to identify how other issues are related to them. There is also a need to introduce a tool to quantitatively assess these issues and to synthesize the findings into an index representing the level of energy security. Such a tool can provide an objective assessment that is as useful to the discussions of decision makers and analysts in the field of energy security as the method that calculates the gross domestic product

(GDP) is to discussants in the field of economics. That is, while economists may hold varying opinions on the economy, they constantly refer to the GDP and its component figures such as government spending, investments and net imports in their discussions (Sharifuddin, 2014).

There are two significance of this study. First, it is not focus on a fuel based definition of energy security (for example oil security or electricity supply security), or limiting energy security dimensions to geopolitics, or to the supply or demand side of energy, but the study argues that energy security is a complex goal involving how to equitably provide available, affordable, reliable, efficient and acceptability.

Second, despite a growing number of studies attempting to measure and quantify energy security have surfaced in the past few years, they reveal distinct areas of overlapping emphases or for specific groups of countries, such as members of the Organization of Economic Cooperation and Development or European Union. They are thus not applicable to developing countries, such as Indonesia, which relatively have immature electricity networks, limited nuclear power units and non-motorized forms of transport. Furthermore, such studies often rely on only a handful of dimensions or metrics that are sectoral in focus, i.e. investigating only electricity, or energy efficiency, or household energy consumption. Therefore, this study synthesizes related literatures into a condensable and usable number of dimensions and metrics looking at multiple sectors and concerns simultaneously.

As discussed in the literature review, four dimensions to evaluate Indonesia’s energy security will be used, i.e. availability, affordability, efficiency and acceptability. These four dimensions then are broke down into 13 composite and simple indicators related to self-sufficiency, diversification of non-fossil fuel, diversification all primary energy sources, remaining production, energy import dependence, oil import cost, primary energy supply per capita, electrification ratio, cost of subsidy, energy intensity and emission intensity. The tool will express each indicator on a 0 to 1 scale to allow multiple indicators to be synthesized into composite scores – one for each core aspect or dimension.

4.2. Methodology and Data

4.2.1 Model Conceptualization

a. Data

Historical data from 2000 to 2012 for evaluating Indonesia's energy security are collected from:

- Energy related data are from Ministry of Energy and Mineral Resources of Republic Indonesia, EIA, World Bank's World Development Index, BP Statistical Review 2014;
- Economic and demographic data are from Indonesia's Statistical Bureau and Ministry of Finance and Ministry of Energy and Mineral Resources of Republic Indonesia.
- Environmental data are from World Bank's World Development Index

b. Determining Dimensions and Indicators

The concept of energy security is developed by gathering the concepts from other works available in the literature review, eliminating the duplicate dimensions and selecting for inclusion only those aspects that can be applied to Indonesia, given their data availability. In conceptualizing energy security, other researchers have relied on interviews, for example Sovacool and Mukherjee (2011); (Vivoda, 2010; von Hippel et al., 2011)as their main tool when determining the dimensions and indicators.Sovacool and Mukherjee (2011) for example, conducted interviews, surveys, workshops and literature review to find that energy security is composed of five dimensions: availability, affordability, technology development, sustainability, and regulation. These five dimensions are then broke down into 20 components and measured by 372 indicators. This study by far has the most extensive concept of energy security.

However, decisions at the national level are not made personally but institutionally. Therefore, we believe that the above approachto determine energy security dimensions of a specific country is not enough in this case. Accordingly, we place greater emphasis on official documents, laws and official statements from the government about their energy policy.

There are two laws that can be referred to determine the energy security dimensions of Indonesia: law No.30/2007 on Energy and Presidential Decree No.5/2006 on National Energy Policy. Table 4.1 below shows how we derived dimensions from the laws' goal.

Table 4.1 Energy Laws and Energy Security Dimensions

Law	Goals	Energy Security Dimensions
Law No.30/2007 on Energy	Energy independency	Availability
	Secure supply of energy both from domestic and abroad	Availability
	Efficient use of energy in all sectors	Efficiency
	Increasing access to energy, especially for less fortunate people and those who live in remote and rural areas	Affordability
	Sustainable, optimal and comprehensive energy resources management	Availability
	Environmental conservation	Acceptability
Presidential Decree No.5/2006 on National Energy Policy	To implement necessary measures to secure energy supply security	Availability
	To reach energy intensity level below 1 by 2025	Efficiency
	Reduce the share of fossil fuel in national energy mix and promoting utilization of renewable energy sources	Availability
	Reasonable price of energy with, including energy subsidy and small business incentives.	Affordability
	Environmental conservation by following sustainable development principles.	Acceptability

The dimensions derived in the above table are sufficient to cover the dimensions of energy security conceptualized in APERC (2007) and other works discussed in the literature review.

c. Corresponding Indicators

After determining the dimensions by referring to the energy laws into four energy security dimensions, the relevant indicators is determined referring to the list of indicators provided in Sovacool and Mukherjee (2011) which is a culmination of the works stemming from the conceptual ofvon Hippel et al. (2011). The adoption of indicators from this well-known concept is sufficiently represents the concepts that are derived through interviews and surveys. There are thirteen indicators determined as shown in Table 4.2 below.

Table 4.2 Energy Security Dimensions and Indicators

Dimension	Indicator	Metric and Unit	Formula
Availability	Self-sufficiency	Share of energy consumptionover domestic production, %	$\frac{\sum C_i}{\sum P_i}$
	Diversification of Non Fossil Fuel	Share of non-fossil fuel energy supply in	$\frac{\sum S_i}{S}$

		TPES, %	
	Diversification total	Diversity of energy source in TPES (SWI)	$-\sum p_i ln(p_i)$
	Remaining Production	Average fossil fuel energy reserve to production, ratio	$\frac{\sum_{i=1}^{n} R_i/p_i}{n}$
	Import Dependence	Fossil energy import in TPES, %	$\frac{\sum M_i}{S}$
	Oil import cost	Share of Oil import value in GDP, %	$\frac{MV_{oil}}{GDP}$
	Primary Energy Supply Percapita	Primary energy supply over population, BOE	$\frac{TPES}{Pop}$
	Electrification ratio	Households with access to electricity compare to total population, %	Simple Indicator
Affordability	Cost of Subsidy	Expenditure in Subsidy as part of Government Spending	$\frac{SUB}{GS}$
	Subsidy	Ratio of energy subsidy to income per capita	$\frac{SUB}{N}$
Efficiency	Energy Intensity	Energy consumption per GDP, BOE/US$	$\frac{\sum C_i}{GDP}$
Acceptability	Emission intensity (energywise)	Energy related CO_2 emission/final energy consumption, $kgCO_2$/BOE	$\frac{EM_i}{C_i}$

	Emission intensity (economywise)	Energy related CO_2 emission per GDP, kgCO2/US$	$\frac{EM_i}{GDP}$

The first dimension is availability, reflects certain major issues, such as the need for the continuous actual existence of energy to sustain Indonesia's socio-economic activities, the country's dependency on fossil fuel and imported energy, and the country's ability to buy oil from abroad and provide reasonable energy prices. The performance of this dimension is described by seven indicators: self-sufficiency, diversification (non-fossil), diversification (total), remaining production, import dependence, oil import cost, and primary energy supply per capita.

The second dimension is affordability, reflects the country's ability to provide comparatively affordable energy to the domestic market. This dimension's performance is indicated by the share of the subsidy within the government spending and the ratio between the amount of subsidy per capita and income.

The efficiency dimension is indicated by the energy intensity. This indicator is often used to represent specific factors that change the energy consumption performance, such as the adoption of more advanced technology and products that result in higher efficiency, fuel switching to more efficient energy carriers and changes in the manner of consuming energy.

The acceptability dimension is mainly related to the climate change issue and is indicated by the ratio of energy-related CO_2emissions (e.g., from fossil fuel combustion) to energy consumption andenergy-related CO_2 emissions for every billion dollars GDP.

d. Energy Security Index Calculation

- Calculating the indicators' value

  This step begins with calculating the value of each metrics using their corresponding formulas as depicted in the table above. With multiple indicators in different units, it is necessary to convert them all to a standard unit in order to allow synthesis of results.

- Normalizing

  We often want to compare scores or sets of scores obtained on different scales. In order to do so, we need to normalize the data by scaling them between 0 and 1, where 0 represent the poorest performance and 1 represent the best performance.The normalizing formula is ad follow

$$NI_j = \frac{I_j - I_{min}}{I_{max} - I_{min}} \qquad \ldots\ldots (1)$$

where,

NI_j = normalized indicator I_j

I_j = indicator I_j

I_{min} = lowest value of indicator I

I_{max} = highest value of indicator I

- Transforming

  Some indicators are expressed in different measurement units and reflect opposing directions (e.g., for import dependence, the lower the better, while for primary energy supply per capita, the higher the better). For the calculation of the composite index, the following metrics have been transformed to their reverse forms: import dependence, oil import cost, cost of subsidy, energy intensity and emission intensity (energy and economy) by subtracting them from 1.

4.3. Result and Analysis

4.3.1 Results

Table 4.3 Results

Year	Self Sufficiency	Diversification of non fossil fuel	Diversificat ion total	Remaining Production	Import Dependence	Oil import cost	PES Percapita
2000	1.00	0.63	0.00	0.62	1.00	0.86	0.00
2001	0.93	0.83	0.30	0.42	0.62	0.94	0.10
2002	0.87	0.37	0.24	0.24	0.50	0.96	0.14
2003	0.75	0.00	0.46	0.13	0.30	1.00	0.27
2004	0.71	0.12	0.20	0.09	0.16	0.54	0.27
2005	0.53	0.25	0.39	0.10	0.00	0.00	0.32
2006	0.18	0.05	0.61	0.00	0.52	0.32	0.29
2007	0.16	0.22	0.69	1.00	0.52	0.37	0.40
2008	0.19	0.32	0.81	0.86	0.78	0.06	0.44
2009	0.26	0.43	0.87	0.85	0.53	0.93	0.44
2010	0.08	1.00	1.00	0.69	0.74	0.82	0.77
2011	0.12	0.12	0.69	0.77	0.84	0.51	1.00
2012	0.00	0.26	0.68	0.74	0.86	0.56	1.00

Table 4.4. Results (continued)

Year	Electrification ratio	Cost of Subsidy	Subsidy	Energy Intensity	Emission intensity (energy wise)	Emission intensity (economy wise)
2000	0.00	0.00	0.68	0.08	0.95	0.07
2001	0.08	0.22	0.54	0.00	1.00	0.00
2002	0.17	0.75	0.97	0.25	0.72	0.19
2003	0.25	0.84	1.00	0.39	0.91	0.39
2004	0.35	0.42	0.63	0.43	0.76	0.41
2005	0.37	0.28	0.43	0.54	0.49	0.47
2006	0.40	0.75	0.75	0.70	0.21	0.63
2007	0.47	0.68	0.62	0.78	0.10	0.71
2008	0.52	0.52	0.23	0.85	0.34	0.83
2009	0.61	1.00	0.97	0.86	0.00	0.80
2010	0.70	0.84	0.73	0.95	0.34	0.95
2011	0.83	0.59	0.22	1.00	0.15	0.99
2012	1.00	0.52	0.00	1.00	0.28	1.00

Indicator scores can be synthesized into scores of dimensions, and then into the ESI. The ESI would be useful to policy makers and analysts as it could act as a reference figure in their discussions. Moreover, discussion is facilitated, as each ESI is comparative to other ESI's calculated for other time periods.

Table 4.4 Dimensions and Energy Security Index

Year	Availability	Affordability	Efficiency	Acceptability
2000	0.51	0.34	0.08	0.51
2001	0.55	0.38	0.00	0.50
2002	0.45	0.86	0.25	0.45
2003	0.43	0.92	0.39	0.65
2004	0.31	0.53	0.43	0.59
2005	0.25	0.35	0.54	0.48
2006	0.31	0.75	0.70	0.42
2007	0.49	0.65	0.78	0.41
2008	0.49	0.38	0.85	0.58
2009	0.64	0.99	0.86	0.40
2010	0.74	0.79	0.95	0.64
2011	0.62	0.41	1.00	0.57
2012	0.63	0.26	1.00	0.64

4.3.2. Comparison to Other Studies

There are three recent studies that uses index method and included Indonesia as one of the observed countries. Sovacool (five dimensions and 20 indicators) and Sharifuddin (five dimensions and 13 indicators). They uses the same set of data but different dimensions and indicators. My study uses four dimensions and 12 indicators where data are collected Ministry of Energy and Mineral Resources of Republic Indonesia, EIA, World Bank's World Development Index, BP Statistical Review 2014, Indonesia's Statistical Bureau, Ministry of Finance of Republic Indonesia and World Bank's World Development Index.

Table 4.5 Security Index Comparison with other studies

Country	Methodology		
	Putra (2015)	Sharifuddin (2014)	Sovacool (2011)
Indonesia	0.59	0.56	0.37
Malaysia	0.55	0.59	0.46
Philippines	0.60	0.62	0.34
Thailand	0.54	0.54	0.31
Vietnam	0.44	0.46	0.28

The results are similar for Putra (2015) and Sharifuddin (2014), slightly different with those af Sovacool (2011) but in the same trend where Thailand and Vietnam are two lowest energy security countries, and Indonesia, Malaysia and Philippines among the top three better energy security scores.

4.3.3. Analysis

a. Availability

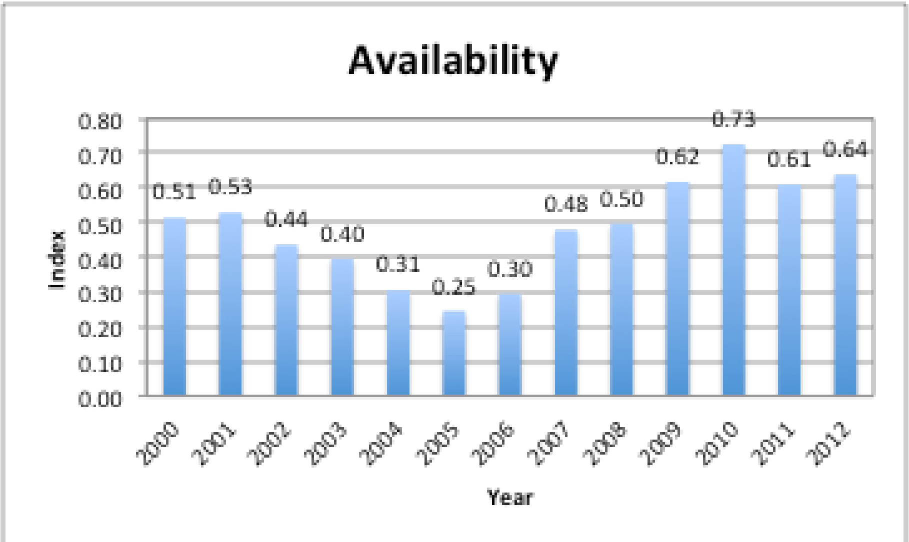

Figure 4.1 Availability dimensions scores

The availability index was increased to 0.53 in 2001 from 0.51 in 2002 before continuously decreased to 0.25 in 2005. After reaching the lowest score in 2005 the performance peaked in 2010 at 0.73, followed by 0.61 and 0.64 in 2011 and 2012.To see how the dimension change in more detail, a series of graphs below depicted a breakdown of the availability dimension into its indicators.

Figure 4.2 shows two indicators in a graph, self-sufficiency and import dependency. Self-sufficiency describes the share of energy consumption over domestic energy production. It shows anegative trend for self-sufficiency over the period. On the other hand, the import dependence indicator that represent by the share of fossil energy import in TPES shows a negative trend from 2000 to 2005 and bounces back in the next consecutive years. This means Indonesia's dependency on energy import is increasing between 2000 and 2005 where it reaches its highest level, and decreasing afterwards.

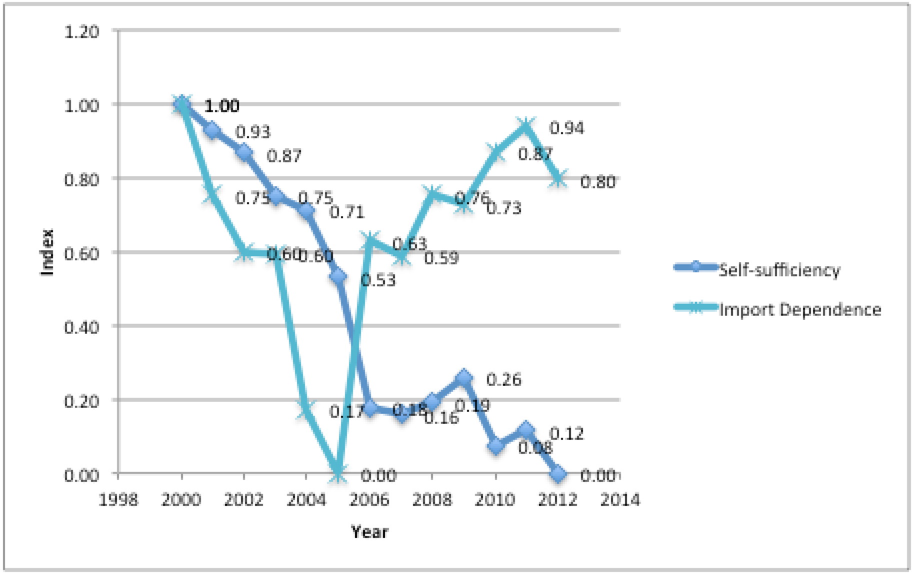

Figure 4.2 Self-sufficiency versus import dependency indicator

The reason behind the decrease of self-sufficiency indicator is quite straightforward; energy consumption grows faster than energy production due to growing economy that demands more energy. On the other hand, the reason behind the performance of import dependence is Indonesia's growing consumption of oil. The consumption surpasses the domestic oil production in 2003, which makes Indonesia a net oil importer country. Energy import is dominated by petroleum products (gasoline) followed by crude oil. However, crude oil import started to decrease in 2005 as gas and coal production and consumption steadily increase. The graph of import dependence bounces back because the production of coal, gas and other primary energy sources are increasing; hence negate the effect of dependence on oil import.

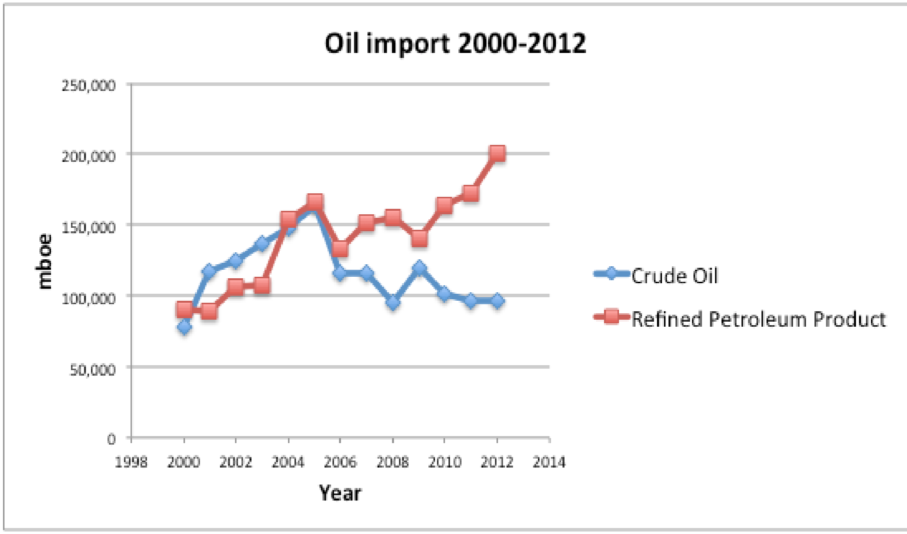

Figure 4.3 Oil import 2000-2012

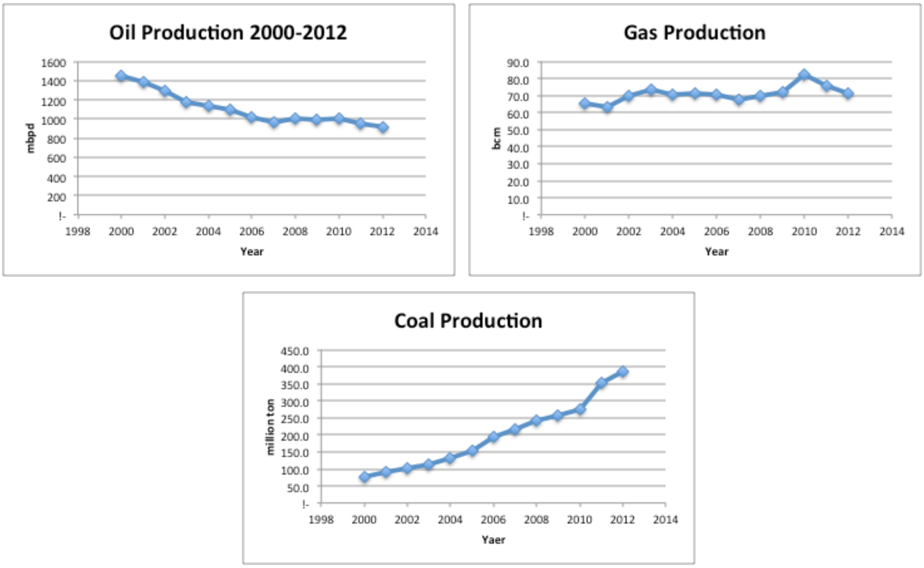

Figure 4.4 Production of oil, gas and coal 2000-2012

Despite the increasing import of oil, government also push energy sources such as gas and coal to be utilized more to domestic market in the recent years to meet the increasing demand. This is also can be verified by the increasing trend of diversification both in non-fossil and fossil energy sources after 2005. Figure 4.4 shows two diversity indicators that represent the share of non-fossil energy sources in TEPS and the overall energy sources diversity index.

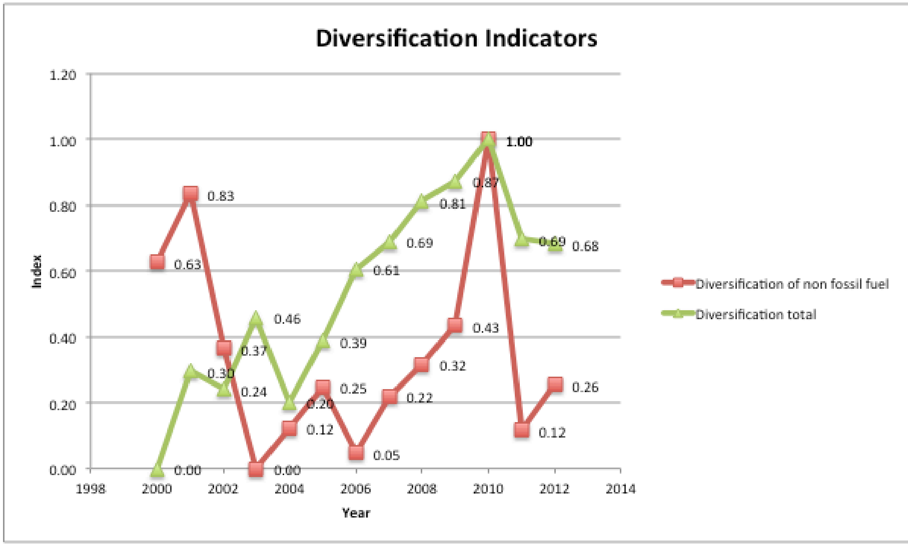

Figure 4.5 Diversity indices

The diversification total indicator shows an increasing trend toward the end of the period of study before it decreases sharply due to decreasing production of hydropower due to severe draught in 2011.Between 2001-2003, the hydropower plants production decreases sharply to the lowest due to the drop of its installed capacity from in 2001. This condition remains relatively the same until 2005.The index for non-fossil fuel diversity shows an upward trend especially after 2006 the Indonesian Government made a firm commitment to the development of biofuel potential in the country. Presidential Instruction No. 1/2006 was issued for the provision and utilization of biofuel in Indonesia as an alternative energy source. Other sources of non-fossil fuel such as hydropower and geothermal also increases. Figure 4.5 shows growing installed capacity of those two main non fossil fuel energy source in Indonesia, where installed capacity are increased significantly after 2005. In 2011 the production of hydropower was dropped by 60%[1] due to a severe dry season affected performance of both indicators.

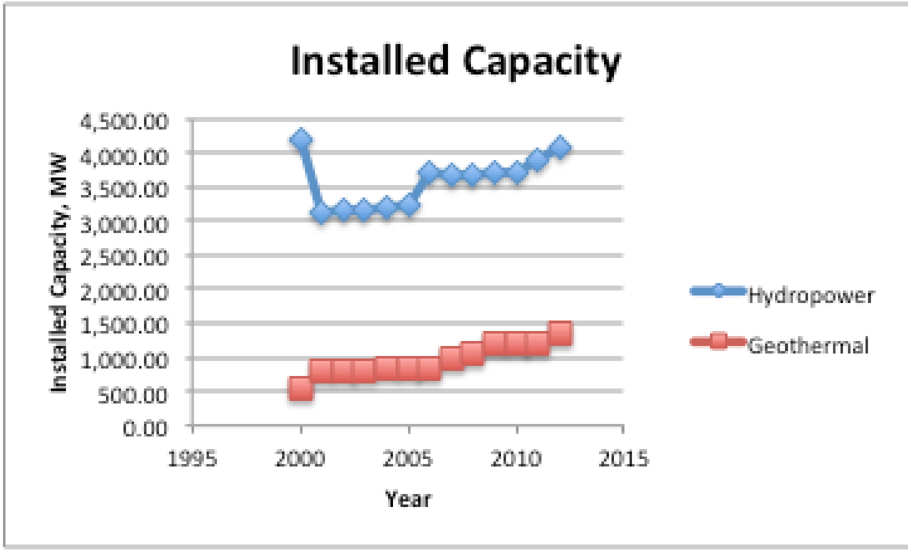

Figure 4.6 Hydropower and Geothermal Installed Capacity

[1]Severe dry season especially in Java Island hampered Hydropower plants due to less stream in the rivers.
http://www.tempo.co/read/news/2011/10/06/177360216/Kemarau-Panjang-Produksi-Listrik-PLTA-Turun-60-Persen

Electrification ratio, performance also increasing annually as the government has targeted to reach approximately 100% of household has access to electricity by 2019. To reach the goal, the government launched two 10000MW fast track electricity generation program. The first fast track program was started in 2006 and is expected to commence in 2014 but suffer from some delay. Most of the power plant from fast track I are coal fired power plant. Hence in the recent years the consumption of coal is started to increase. The latter was started in 2012 and is expected to commence in 2016.

Primary energy supply per capita is also increasing over year. In order to keep sufficient domestic energy supply, the government has been shifted some export of energy commodity such as gas and coal into domestic market. The government also tried to increase the role of renewable energy in the national energy mix. The most significant development comes from geothermal and hydropower sector, which is expected to be the major renewable energy source in reaching 17% energy mix, target from renewable energy by 2025.

The remaining production that measures reserve to production ratio, increase relatively high in 2009 and 2012, compared to the previous years. This is mostly due to the data correction of proven reserve of coal as the result of government study in 2007[2]. This made the availability of coal in domestic market lasts for 75 years with current production rate.

b. Affordability

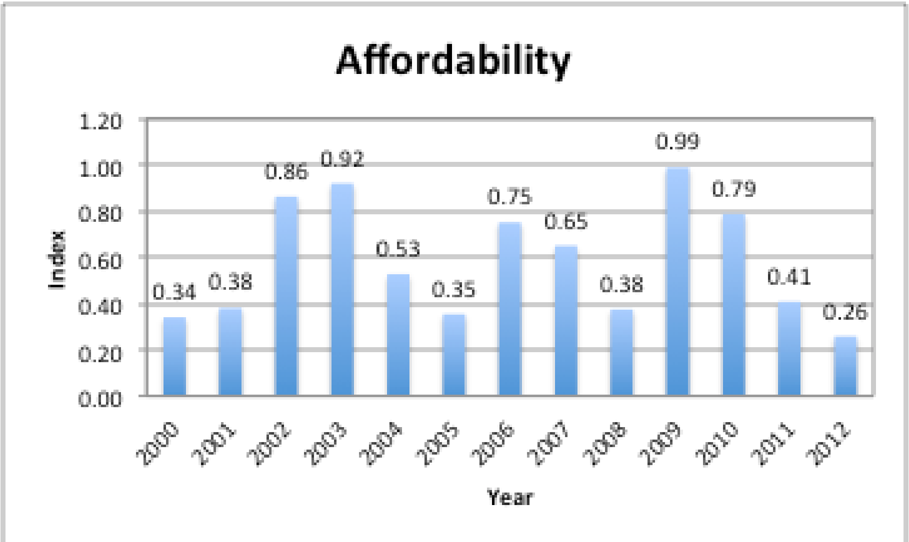

Figure 4.7 Affordability Scores

[22]A joint study between Ministry of Energy and Mineral Resources and NEDO revised the amount of coal reserves in late 2008 (http://industri.kontan.co.id/news/joint-study-batubara-dengan-jepang-akhirnya-kelar)

The score for this indicator is fluctuating during the period of study. The score is generally reached its peaks in 2003, 2006 and 2009. On the other hand it reaches lowest scores in 2000, 2005 and 2012. Both indicators that represent this dimension i.e. cost of subsidy (subsidy expenditure as part of government budget) and subsidy (ratio of energy subsidy per income per capita).

The elimination of fuel subsidy would greatly affect this dimension in terms of people's ability to buy petrol/electricity and on the cost of the subsidy in government spending. As can be seen in Figure 10, both graph oscillate in similar pattern but in different trend. In 2000 the government reduce the subsidy by increasing the price of gasoline by almost twofold from Rp. 600/L to 1150/L. Despite of this subsidy reduction, the government still subsidizes the fuel heavily. The price continues to increase as can be seen in Table 4.6 below:

Table 4.6 Subsidy reduction on gasoline price

Year	Gasoline Price (Rp./Liter)
2000	1150
2001	1450

2002	1550
2003	1800
2005	2400
2005	4500
2008	6000
2008	5500
2008	5000
2009	4500

The effect of subsidy reduction is the less the subsidy cost in government budget, the better the performance, on the other hand, the people worse off in term of the increasing burden of fossil fuel in their GDP percapita.

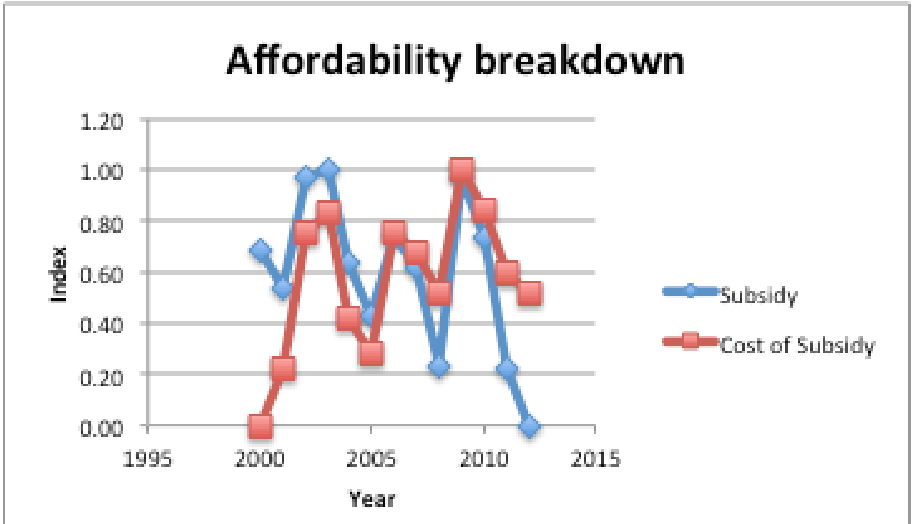

Figure 4.8 Affordability breakdown

c. Efficiency

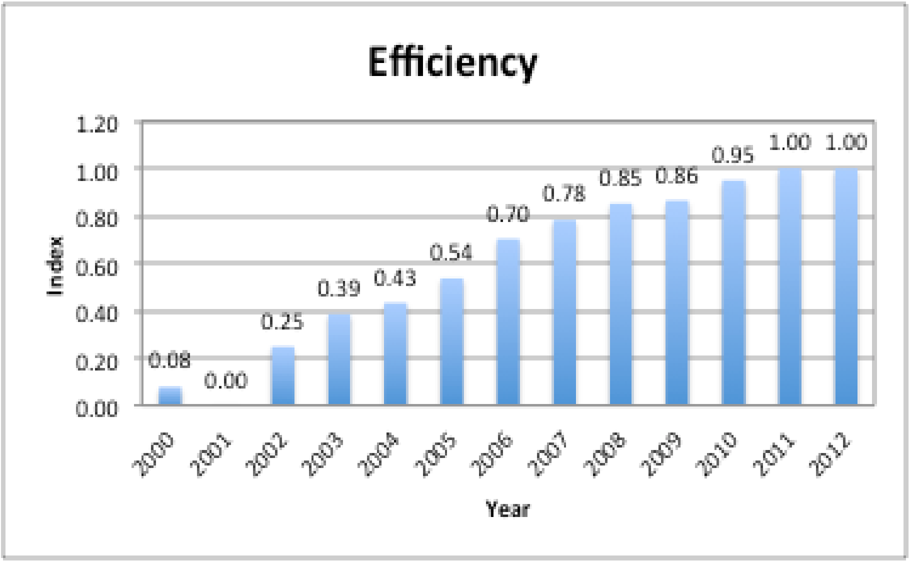

Figure 4.9 Efficiency

This dimension score's is increasing steadily from 2000 to 2012. This can be explained by the findings of some study that found positive relationship between energy consumption and economic growth in Indonesia. Masih and Masih (1996), analysed and confirmed the positif relationship of energy consumption and economic growth of Indonesia from 1955 to 1990. Other related study on the relationship between energy consumption and economic growth of Indonesia by Hwang and Yoo (2014) and Soares et. al (2014) also indicate the presence of a strong statistical relationship between GDP and energy consumption in Indonesia.

The score in 2001 is relatively the lowest during the period of study. This is due to the slightly lower GDP in 2001 compared to 2000 and the following years. The GDP was US$ 165,021,012,261.509 in 2000, down to US$ 160,446,947,638.313 in 2001 and bounce back to US$ 195,660,611,033.849 in 2002. The GDP continue to grow positively and reaches US$ 876,719,347,689.156 in 2012. The role of non-fossil fuel sources of energy also plays positive impact in these indicators.

d. Acceptability

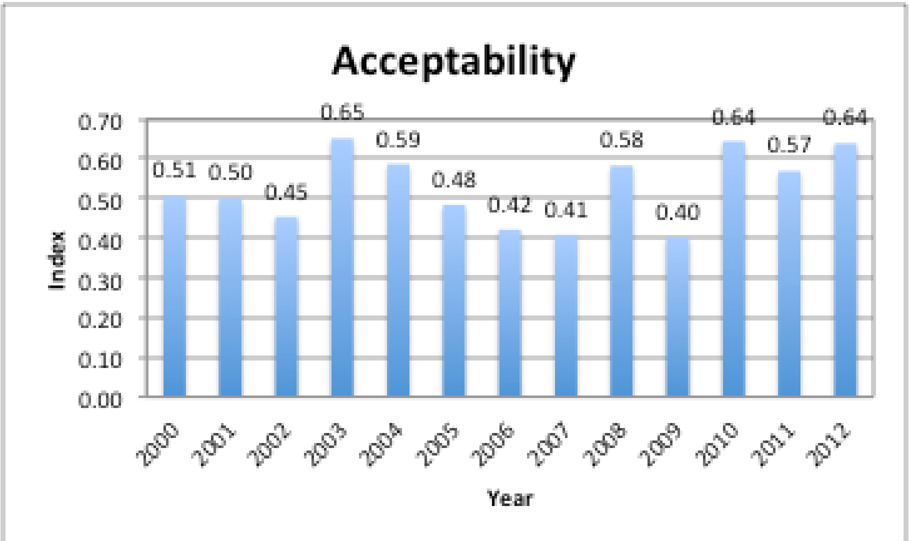

Figure 4.10 Acceptability

This dimension represented by two indicators, emission intensity (economy wise) that describes energy related CO_2 emission over GDP, and emission intensity (energy wise) that describes share of CO_2 emission over final energy consumption. The score fluctuate between 2000 and 2012. This is due to the different effect of two indicators that represents this dimension as shown in Figure 4.10.

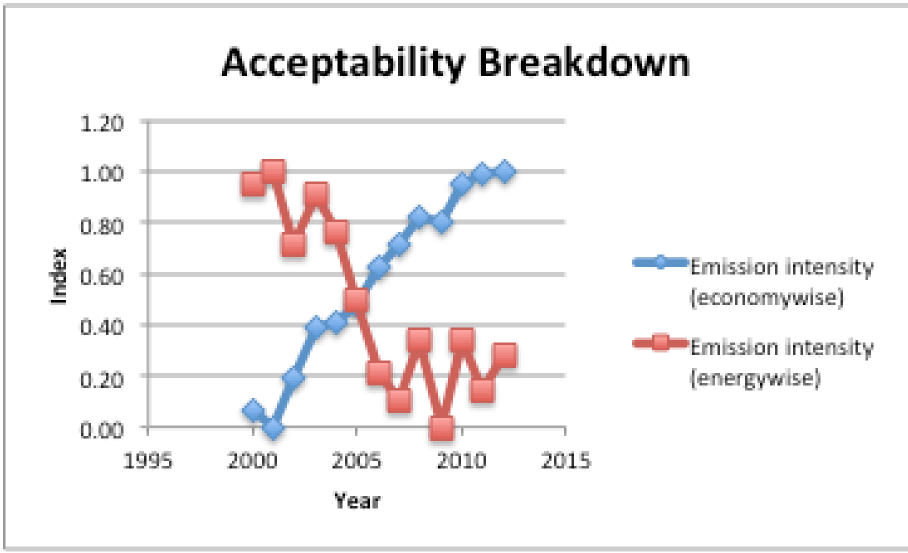

Figure 4.11 Acceptability breakdown

The score for emission intensity in terms of energy (energy related CO_2 emission per energy consumption) is worsening over the period of study. As the economy grows energy demand become higher and the consumption of energy, mainly fossil fuels, are also increasing. Therefore CO_2 emission increases accordingly. Figure 4.11 shows the energy mix of Indonesia in 2000, 2006 and 2012. Fossil fuels still take the dominant part, especially coal which consumption grows significantly from only 9.42% in 2000 to 22.44% in 2012.

On the other hand, the emission intensity indicator in terms of economy (energy related CO_2 emission per GDP) shows a positive trend. This means that Indonesia emits less $CO_2$to achieve higher GDP over the years. If we look back to the efficiency dimension where energy consumption is increasing with GDP, this indicates that the role of non fossil fuel in energy consumption is becoming more significant in reducing CO_2 emission from energy sector.

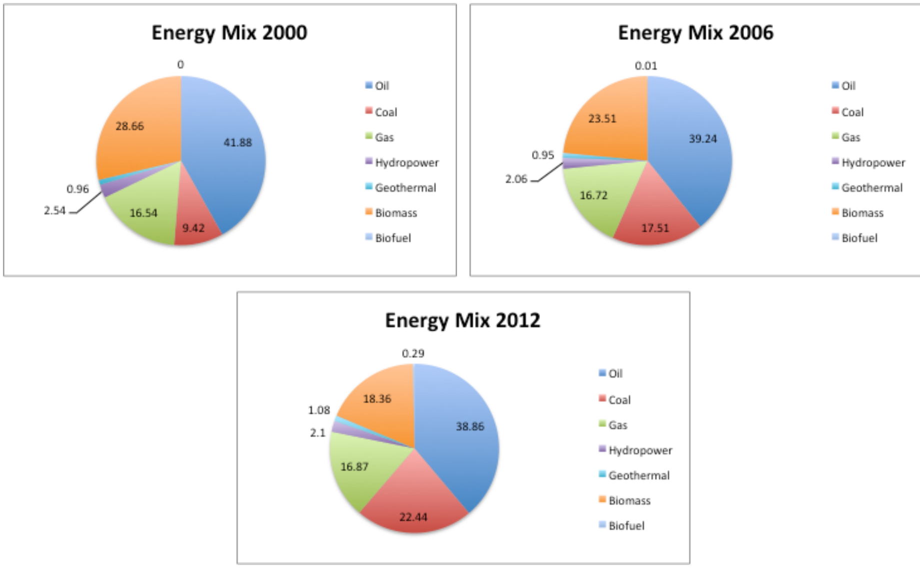

Figure 4.12 Indonesia Energy Mix

4.4. Conclusions and Policy Implications

Since mid-2000s, energy security has been a priority for the government of Indonesia. Indonesian government realize that, as a rapidly developing country, how the government manages its resources and enacts policies to balance domestic use and supply is critical. The state plays a prominent role in regulating and managing the country's energy and natural resources, as stated in the 1945 Constitution. The Ministry of Energy and Mineral Resources defines its first priority as ensuring energy security and independence, with an emphasis on domestic supply of energy sources.

Despite the attempt to diversify energy sources, Indonesia still has to address the problem of how to eliminate its energy subsidies. It is true that the main goal for the subsidies is to enable low purchasing power people to consume fuel, but the negative implications of this policy seem to be so obvious. Indriyanto et al. (2007) argued that subsidies tend to cause overconsumption of the resource, since the market price does not reflect the actual cost of producing one unit of petroleum product. They also discourage energy efficiency measures and the development of alternative or renewable energy sources by way of low electricity tariffs. The state budget is heavily burdened by this policy and in order to provide low priced electricity, they are denying access to nearly half the population.

This study proposes an index method to evaluate energy security performance of Indonesia between 2000 and 2012. The selection of dimensions is based on the existing energy law set out some goals on the energy security of Indonesia. It also refers to vast existing references about energy security index.

Indonesia's energy policy has focused primarily on the availability dimension. This focus is reflected in the Presidential Decree No. 5/2006 on National Energy Policy and Law No. 30/2007 on Energy, in which self-sufficiency and the diversification of fossil energy are the main priorities. This is a reasonable option due to Indonesia's abundance of coal and gas. Concern over the environmental dimension, such as CO_2 emission, remains rather low because the biggest contributor to Indonesia's CO_2 emissions is the forestry sector. However, the regional and international pressure on this issue is increasing.

To quantitatively assess the energy security of Indonesia, the tool in this study is builds upon existing works by overcoming the impediment on applicability of those works posed by limited data availability of Indonesia. Started by selecting dimensions based on existing energy law and match them with existing indicators comprehensively provided by other study.

There are 13 indicators grouped into four core aspects of energy security i.e. availability, affordability, efficiency and acceptability. The indicator scores can be synthesized into scores of indicators and dimensions. This is possible through this methodology's normalization process.

The availability dimension of energy security of Indonesia has eight indicators attached to it. This dimension has the lowest score in 2005 when Indonesia have just become a net oil importer country. The government effort to reduce oil consumption can be seen from the increasing of diversification index where the role of non-fossil fuel energy source such as hydropower, geothermal and biofuel, as well as fossil fuel such as coal and gas are increasing. The government policy is quite successful, where the availability index after 2005 is increasing.

The affordability dimension shows the effect of fuel subsidy reduction on both government budget and average people income which represented by GDP per capita. Both indicators move in opposite direction that is subsidy reduction eases government budget but in contrary increase people's budget allocation for fuel. However this effect eventually will be paid off by more money in government budget to serve the people.

The third dimension is efficiency, which measure energy consumption over GDP. The result shows that government policy in promoting energy efficiency as stipulated in the energy laws are successful. The scores are continuously increasing except in 2001 due to economic downturn that affect the GDP in that year.

The last dimension is the acceptability where two indicators measure the share of energy related emission over energy consumption and GDP. This is dimensions shows that Indonesia emits less CO_2 to achieve higher GDP over the years. Referring to the efficiency dimension where energy consumption is increasing with GDP, and there are less CO2 emitted per unit of GDP indicates that the role of non-fossil fuel in energy consumption is becoming more significant in reducing CO_2 emission from energy sector.

The issue of energy security has been the subject of discussion in Indonesia for a long time. However, until the end of the 1990s, it had never been central to the country's policy debates. The turning points were the sharp depreciation of the Rupiah during the 1997/98 Asian financial crisis and the increasing prices of crude oil in the early 2000s which made it very expensive to control the domestic price of fuel and electricity through subsidies. With approximately 43 percent of the country's energy sources derived from crude oil, the amount of government spending on the energy subsidy increased from almost nothing in 1996 to approximately 24 percent of total government expenditure in 2000.

The issue of energy security became even more complex when in 2003-2004 for the first time in several decades, Indonesia became a net importer of oil and in the late 2000s with the emergence of climate change issues. Flowing from production decline, Indonesian crude oil exports have also been declined as the government decided to prioritize domestic crude oil consumption over exports. As a result of this, Indonesia enacted the Presidential Decree no 5/2006 on National Energy Policy in 2006— a policy that explicitly pushes the country to reduce its reliance on crude oil and seek other energy sources— and decided to withdraw from the

Organization of the Petroleum Exporting Countries (OPEC) in 2008.

Imports, on the other hand, have increased along with increasing consumption and decreasing production in the first half of this decade. The Presidential Decree no 5/2006 has made it a priority to shift away from oil and increase coal and natural gas consumption, explaining the more recent decline in crude oil imports. While the government is trying to rely less on oil, it is still the main fossil fuel used throughout the country and, as with energy consumption, there is increasing demand for refined petroleum products such as gasoline. Lack of investment in additional domestic refineries made way for increases in imported refined fuels, thus increasing Indonesia's vulnerability to international oil price fluctuations.

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Lack of investment in additional domestic refineries made way forincreases in imported refined fuels, thus increasing Indonesia’s vulnerability to international oil price fluctuations.

This study shows that policy toward reducing energy consumption through energy subsidy elimination should be given more priority as it is shown from the result that the affordability dimensions actually has a positive trend instead of the energy subsidy reduction between 2000 and 2012. The policy that improve the diversification of primary energy supply, can also affect the energy security performance positively.

Since assessment is made at the national level, it is important to emphasize that this tool potentially does not capture some aspects of energy security. As such, there is room to significantly improve this tool by developing compatible methodologies to approximate these elements, and to integrate the results into this tool.

5. Essay 2: Gas Supply Security Index in Indonesia

5.1. Introduction

The growing demand for gas, increasing gas prices, transportation and distribution bottlenecks, and a growing concern on reliance on imports in the near future have raised concerns on domestic gas supply security in Indonesia. Its consumption is expected to increase in the future because of its low environmental impact, ease of use and an increase in the number of natural gas-fired power plants. In recent years, the demand for natural gas, as an alternative energy source for less environmentally–friendly and less efficient resources such as oil and coal has already significantly increased, as shown in Chapter 3.

The Indonesia Gas Balance (MEMRb, 2015) in Figure 5.1 shows how total domestic gas demand is actually above total domestic gas supply (including import). Despite the increasing domestic demand, the fact that Indonesia will have to import gas from other countries in 2019 is also because lack of domestic gas infrastructure such as gas pipeline, LNG Terminal and LNG regasification terminal.

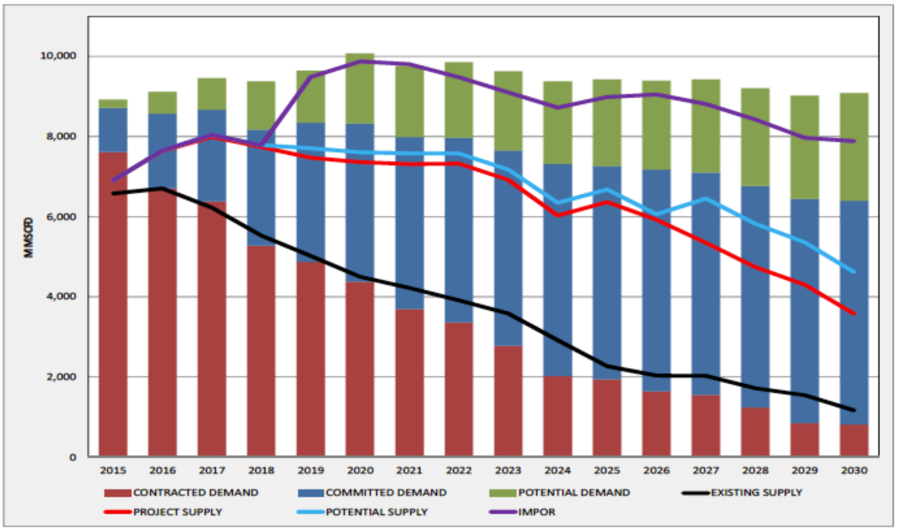

Figure 5.1 Indonesia Gas Balance 2015-2030 (MEMR.b, 2015)

Figure 5.2 Indonesia Gas Infrastructures (MEMR.a, 2015)

This study will use a Gas Supply Security Index (GSSI) method to show that the index will improve by constructing more gas infrastructure among regions and combining several interconnected regions in Indonesia's gas market.

A number of studies have tried to develop a set of energy supply security indicators to account for disruptions. Although a number of indicators have been proposed in the literature, there is no consensus on a set of relevant indicators. As a result, time series data to directly assess trends in energy supply security are not readily available and policy makers have therefore relied on a number of parameters associated with energy security to inform decision making.

The objective of this chapter is to evaluate a set of gas supply security indicators including gas intensity, net gas import dependency, ratio of domestic gas production to total domestic gas consumption, for several regions in Indonesia's Natural Gas Balance 2015 -2030 (MEMRb, 2015). It proposes a composite gas supply security index (GSSI) that is derived as the root mean square of the scaled values of four security of gas supply indicators (Gnansounou, 2008).

Cabalu (2010) adopted Gnansounou (2008) method and applied it to evaluate gas supply security in seven Asian countries. Cabalu (2010) uses four security of gas supply indicators are interrelated and that the GSSI derived provides a composite quantitative measure of gas security by taking into account the interactions and interdependence between the identified set of indicators. The GSSI captures the sensitivity of the domestic gas market, with a higher index indicating higher gas supply insecurity or vulnerability for a specific region.

This approach can be implemented to evaluate Indonesia's domestic gas supply security since Indonesia's domestic gas supply isgrouped into several regions based on gas and infrastructure availability. This study will omit one of the four indicators named geopolitical risk since the domestic gas market does not pose any of such risk.

This paper is important in terms of providing metrics by evaluating a set of parameters and indicators to assess overall natural gas supply security in several Indonesia's domestic gas market. It is important for future policy making to benchmark against quantified indicators and assessesthe gas security of supply weakness.

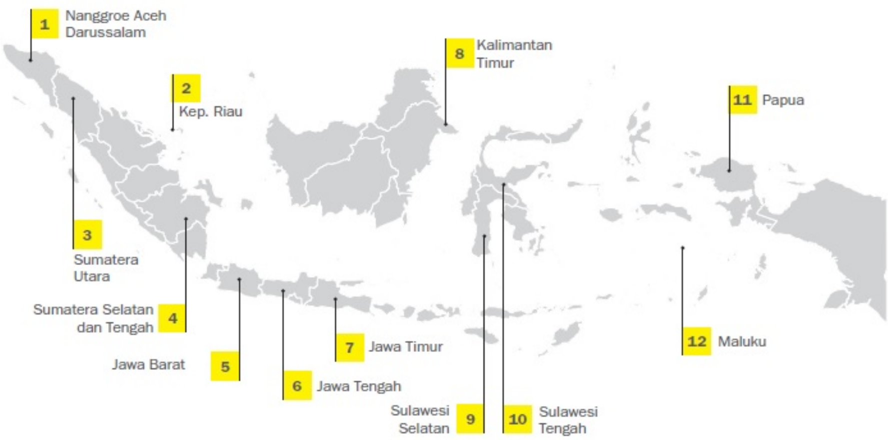

Figure 5.3 Indonesia Gas Regions (MEMRa, 2015)

In the previous edition of Indonesia Gas Balance, there are 12 regions that are established based on availability of gas sources and infrastructures. Based on the recent development, these regions can be grouped into nine (based on geographical and economic development condition) and six regions (based on geographical and economic development and infrastructure availability condition). Some regions in the eastern part of Indonesia such as Sulawesi Tengah, Sulawesi Selatan, Masela and Papua are big gas producers but these regions are less populated and less developed. So they are actually can be grouped into one region. On the other hand, in the Western part of Indonesia Nangroe Aceh Darussalam and Sumatera Utara can be grouped into one region as it is now connected by a newly constructed pipeline. Some other region such as Kepulauan Riau, Sumatera Selatan dan Tengah and Jawa Bagian Barat can also be grouped into one region as they are interconnected with extensive gas pipeline. Table 5.1 shows how the regions are grouped and will be evaluated.

Since transporting gas between islands is quite a big challenge, it is necessary to develop Liquefied Natural Gas Regasification Unit and more gas pipeline network that connects several neighboring yet isolated region should be a key to boost natural gas distribution among regions. To test effectiveness of this policy, this study tries to test the GSSI of six regions and compare it to the nine regions.

Table 5.1 Previous and Proposed Regions

No.	Nine Regions	Six Regions
1.	Nangroe Aceh Darussalam (NAD)	NAD and Sumatera Bagian Utara
2.	Sumatera Bagian Utara	Sumatera Bagian Selatan and Tengah, Kepulauan Riau, Jawa Bagian Barat
3.	Sumatera Bagian Selatan and Tengah	Jawa Bagian Tengah
4.	Kepulauan Riau	Jawa Bagian Timur and Bali
5.	Jawa Bagian Barat	Kalimantan Bagian Timur
6.	Jawa Bagian Tengah	Papua, Sulawesi Selatan, Sulawesi Tengah and Masela
7.	Jawa Bagian Timur and Bali	
8.	Kalimantan Bagian Timur	
9.	Papua, Sulawesi Selatan, Sulawesi Tengah and Masela	

The paper is structured as follows: section 5.1 explains the approach of the study, followed by section 5.2 which will provide the methodology, conceptualization, definition and construction of the model. Section 5.3 will provide results and analysis, and Section 5.4 presents the conclusions and policy implications.

5.2. Methodology and Data

5.2.1 Model Conceptualization

A number of studies have focused on assessing energy vulnerability. The design of a composite index of energy security has been undertaken in previous studies. A composite vulnerability index was developed by the World Energy Council (2008) to benchmark and monitor European countries' respective efforts to cope with long-term energy vulnerability. Similarly, de Jong et al. (2007) designed state-of-the-art indexes of energy security risk (i.e., the crisis capability index and supply/demand index) which are oriented towards a comprehensive and analytical representation of the energy supply chain. However, the shortcoming of these approaches was the use of subjective-opinion-dominated weighting systems and scoring rules where the weights and the rules were based on expert judgements.

In response to this shortcoming, Gnansounou (2008) proposed an alternative method which was objective-value-oriented and statistics-based. The author defined the composite index as the Euclidean distance to the best energy security case represented by the zero point. The Euclidean distance is standardized in order to get a value between 0 and 1. A study by Cabalu (2010) is made based on Gnansounou principle to observe natural gas supply disruptions among several Asian countries based on four indicators of security of supply i.e. gas intensity, net gas import dependency, ratio of gas consumed in a an economy to gross domestic product (GDP) and geopolitical risk. This study can be applied to Indonesia's case since Indonesia is an archipelagic country which consists of thousand islands and less interconnection between gas production regions and gas consuming regions. Since there are no political issues between regions in Indonesia, the last indicator can be omitted.

In line with the analyses made in previous literature, three distinct security of supply indicators were selected for this study:

I. Gas intensity (G1),

$$G_1 = \frac{GC_j}{RGDP_j} \qquad (1)$$

G1 is measured as the ratio of gas consumed in an (regional/local) economy to regional gross domestic product (RGDP). It is the amount of natural gas needed to produce a dollar's worth of goods and services and provides an indication of efficient use of gas to produce the economy's output.

II. Net gas import dependency (G2)

$$G_2 = \frac{GM_j}{TPEC_j} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

G2 is expressed as the ratio of net imported gas consumption to total primary energy consumption.

III. Ratio of domestic gas production to total domestic gas consumption (G3).

$$G_3 = \frac{GP_j}{GC_j} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

G3 is measured as the ratio of domestic gas production to total domestic gas consumption. Domestic production is a better indicator of the regions' capacity to cope with short-term supply disruption than domestic reserves as production excludes gas from stranded reserves which cannot be tapped immediately.

To facilitate comparison or aggregation of several indicators, it may be better for these to be expressed in the same units. To do this, for each of the four security indicators, a relative indicator j_i, was estimated which was used to compute a composite index—gas supply security index (GSSI). The relative indicators were estimated by using a scaling technique where the minimum value is set to 0 and the maximum to 1. The value of 0 is assigned to the region with the least vulnerability or insecurity to supply disruptions and value 1 is assigned to the region with the most vulnerability to supply shocks.

Following Gnansounou (2008), the gas supply security index (GSSI) is derived as the root mean square of the three relative indicators or scaled values of the three security of supply indicators:

$$GSSI_j = \cdots \sqrt{\frac{\sum_{i=1}^{3} \varphi_{ij}^2}{3}} \quad \text{...(4)}$$

The relative indicator for region j associated with $G_1(\varphi_{1j})$ estimated as:

$$\varphi_{1j} = \frac{G_{ij} - Min(G_1)}{Max(G_1) - Min(G_1)} \quad \text{...(5)}$$

The relative indicator, φ_{1j} results in projection of G_{1j} in the interval [0, 1]. A low value of φ_{1j} means that region j is less vulnerable or less insecure to supply shocks compared with other regions in the study.

Similarly, the relative indicator for country j associated with G_2 (φ_{2j}) is estimated as

$$\varphi_{2j} = \frac{G_{2j} - Min(G_2)}{Max(G_2) - Min(G_2)} \quad \text{.......................................(6)}$$

The above adjustment transforms the indicator in the [0, 1] interval with the value of 0 being assigned to the region with the lowest value of the selected security of supply indicator and least.

This third indicator, unlike the first two, is negatively related to gas supply vulnerability or security. A high value for G_3 means that region j is less vulnerable or less insecure to supply shocks compared with other countries in the study. To accommodate this negative relationship, the relative indicator for country j associated with G_3 (φ_{3j}) is estimated as

$$\varphi_{3j} = \frac{Max(G_3) - G_{3j}}{Max(G_3) - Min(G_3)} \qquad (7)$$

5.3. Data and Results

5.3.1. Data

Data are obtained from the Indonesian Natural Gas Outlook 2015-2030 (MEMR, 2015) with some supportive data are accessed from Indonesian statistical Bureau website (RGDP data). Most of the regions are not literally imported gas from other region except Jawa Bagian Barat and NAD. However the deficit between supply and demand is translated into import to reflect the vulnerability of those regions to gas supply shortage.

Table 5.2 Nine Regions Indicators Data

Region		Supply		Demand		GRP	TPEC
		Domestic	Import	Domestic	Export		
		mmscfd	mmscfd	mmscfd	mmscfd	trillion Rp.	million boe
I	Nangroe Aceh Darussalam	53,4	0	87	0	130,45	23,48
II	Sumatera Bagian Utara	10,6	0	83	0	523,77	65,75
III	Sumatera Bagian Selatan and Tengah	1835	0	980	368	1141,96	37,94
IV	Kepulauan Riau	544	0	82	658	182,92	9,15
V	Jawa Bagian Barat	644	918	1534	0	3580,13	323,83
VI	Jawa Bagian Tengah	39	0	155	0	925,66	160,05
VII	Jawa Bagian Timur and Bali	554	0	756	0	1697,14	204,01
VIII	Kalimantan Bagian Timur	1765	0	689	1195	519,93	16,02
IX	Papua, Sulawesi Selatan, Sulawesi Tengah and Masela	1340	0	461	847	603,58	80,57

Table 5.3 Six Regions Indicators Data

Region		Supply		Demand		GRP	TPEC
		Domestic	Import	Domestic	Export		
		mmscfd	**mmscfd**	**mmscfd**	**mmscfd**	**billion Rp.**	**million boe**
I	NAD and Sumatera Bagian Utara	64	0	170	0,00	654,21981	168,6
II	Sumselteng, Kepri, Jabar	2803	220	2596	1026,00	4905,00215	416,442
III	Jawa Bagian Tengah	39	0	155	0	925,66	160,05
IV	Jawa Bagian Timur dan Bali	554	0	756	0	1697,14	204,01
V	Kalimantan Bagian Timur	1765	0	689	1195	519,93	16,02
VI	Papua, Sulawesi Selatan, Sulawesi Tengah and Masela	1340	0	461	847	603,58	80,57

5.3.2. Results

Table 5.4 Nine Regions Indicators Results

	Region	G_1	G_2	G_3
I	Nangroe Aceh Darussalam	0,67	0,00	0,61
II	Sumatera Bagian Utara	0,16	0,00	0,13
III	Sumatera Bagian Selatan and Tengah	0,86	0,00	2,25
IV	Kepulauan Riau	0,45	0,00	14,66
V	Jawa Bagian Barat	0,43	2,83	0,26
VI	Jawa Bagian Tengah	0,17	0,00	0,25
VII	Jawa Bagian Timur and Bali	0,45	0,00	0,73
VIII	Kalimantan Bagian Timur	1,33	0,00	4,30
IX	Papua, Sulawesi Selatan, Sulawesi Tengah and Masela	0,76	0,00	4,74

Table 5.5 Nine Regions Relative Indicators Results

	Region	g_1	g_2	g_3
I	Nangroe Aceh Darussalam	0,44	0,00	0,97
II	Sumatera Bagian Utara	0,00	0,00	1,00
III	Sumatera Bagian Selatan and Tengah	0,60	0,00	0,85
IV	Kepulauan Riau	0,25	0,00	0,00
V	Jawa Bagian Barat	0,23	1,00	0,99
VI	Jawa Bagian Tengah	0,01	0,00	0,99
VII	Jawa Bagian Timur and Bali	0,25	0,00	0,96
VIII	Kalimantan Bagian Timur	1,00	0,00	0,71
IX	Papua, Sulawesi Selatan, Sulawesi Tengah and Masela	0,52	0,00	0,68

Table 5.6 Nine Regions GSSI Results

	Region	GSSI
I	Nangroe Aceh Darussalam	0,61
II	Sumatera Bagian Utara	0,58
III	Sumatera Bagian Selatan and Tengah	0,60
IV	Kepulauan Riau	0,14
V	Jawa Bagian Barat	0,82
VI	Jawa Bagian Tengah	0,57
VII	Jawa Bagian Timur and Bali	0,57
VIII	Kalimantan Bagian Timur	0,71
IX	Papua, Sulawesi Selatan, Sulawesi Tengah and Masela	0,49

Table 5.7 Six Regions Indicators Results

	Region	G_1	G_2	G_3
I	NAD and Sumatera Bagian Utara	0,26	0,00	0,38
II	Sumselteng, Kepri, Jabar	0,53	0,53	1,36
III	Jawa Bagian Tengah	0,17	0,00	0,25
IV	Jawa Bagian Timur dan Bali	0,45	0,00	0,73
V	Kalimantan Bagian Timur	1,33	0,00	4,30
VI	Papua, Sulawesi Selatan, Sulawesi Tengah and Masela	0,76	0,00	4,74

Table 5.8 Six Regions Relative Indicators Results

	Region	g_1	g_2	g_3
I	NAD and Sumatera Bagian Utara	0,08	0,00	0,97
II	Sumselteng, Kepri, Jabar	0,31	1,00	0,75
III	Jawa Bagian Tengah	0,00	0,00	1,00
IV	Jawa Bagian Timur dan Bali	0,24	0,00	0,89
V	Kalimantan Bagian Timur	1,00	0,00	0,10
VI	Papua, Sulawesi Selatan, Sulawesi Tengah and Masela	0,52	0,00	0,00

Table 5.9 Six Regions GSSI Results

	Region	GSSI
I	NAD and Sumatera Bagian Utara	0,56
II	Sumselteng, Kepri, Jabar	0,75
III	Jawa Bagian Tengah	0,58
IV	Jawa Bagian Timur dan Bali	0,53
V	Kalimantan Bagian Timur	0,58
VI	Papua, Sulawesi Selatan, Sulawesi Tengah and Masela	0,30

5.4. Sensitivity Analysis

5.4.1. Allowing gas import from other region/countries by means of LNG Regasification Terminal

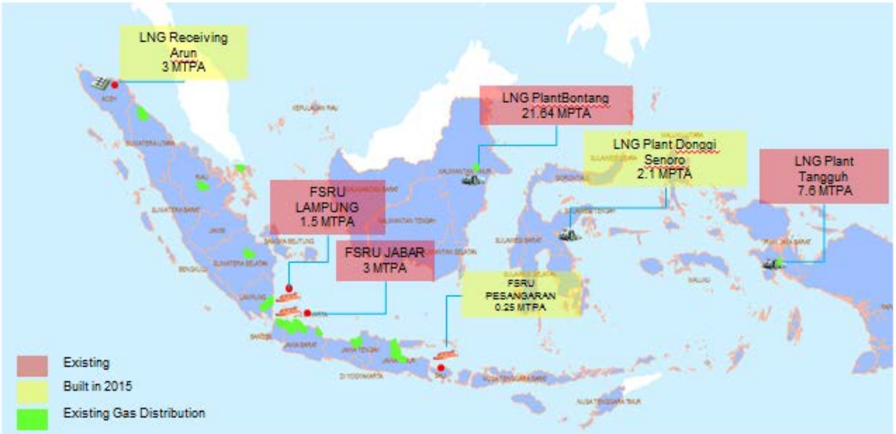

Figure 5.4 LNG Plant and Regasification Terminal Development

The development of LNG Plants and LNG Regasification terminals will help gas deficit regions to import gas from other regions or from other countries. Table below shows the sensitivity analysis of the previous data with the possibility of importing gas through LNG Terminals.

Table 5.10 GSSI of 9 Regions after Development of LNG Plants and LNG Regasification Terminals

Region		Supply		Demand		GSSI (After)	GSSI (Before)
		Domestic	**Import**	**Domestic**	**Export**		
		mmscfd	**mmscfd**	**mmscfd**	**mmscfd**		
I	Nangroe Aceh Darussalam	53,4	33,6	87	0	0,59	0,61
II	Sumatera Bagian Utara	10,6	72,4	83	0	0,58	0,58
III	Sumatera Bagian Selatan and Tengah	1835	0	980	368	0,46	0,60
IV	Kepulauan Riau	544	196	82	658	0,60	0,14
V	Jawa Bagian Barat	644	918	1534	0	0,57	0,82
VI	Jawa Bagian Tengah	39	116	155	0	0,57	0,57
VII	Jawa Bagian Timur and Bali	554	202	756	0	0,53	0,57
VIII	Kalimantan Bagian Timur	1765	119	689	1195	0,63	0,71
IX	Papua, Sulawesi Selatan, Sulawesi Tengah and Masela	1340	0	461	847	0,30	0,49

Table 5.11 GSSI of 6 Regions after Development of LNG Plant and LNG Regasification Terminal

Region		Supply		Demand		GSSI (After)	GSSI (Before)
		Domestic	Import	Domestic	Export		
		mmscfd	mmscfd	mmscfd	mmscfd		
I	NAD and Sumatera Bagian Utara	64	106	170	0,00	0,56	0,56
II	Sumselteng, Kepri, Jabar	2803	819,00	2596	1026,00	0,51	0,75
III	Jawa Bagian Tengah	39	116	155	0	0,58	0,58
IV	Jawa Bagian Timur dan Bali	554	202	756	0	0,55	0,53
V	Kalimantan Bagian Timur	1765	119	689	1195	0,83	0,58
VI	Papua, Sulawesi Selatan, Sulawesi Tengah and Masela	1340	0	461	847	0,30	0,30

5.4.2. Development of Jawa Bagian Tengah – Jawa Bagian Timur pipeline in 2016

The development of transmission pipeline between the two regionsis planned to be completed by 2016. This sensitivity analysis will look at the effect of combining these two adjacent regions into one on the GSSI index of the region.

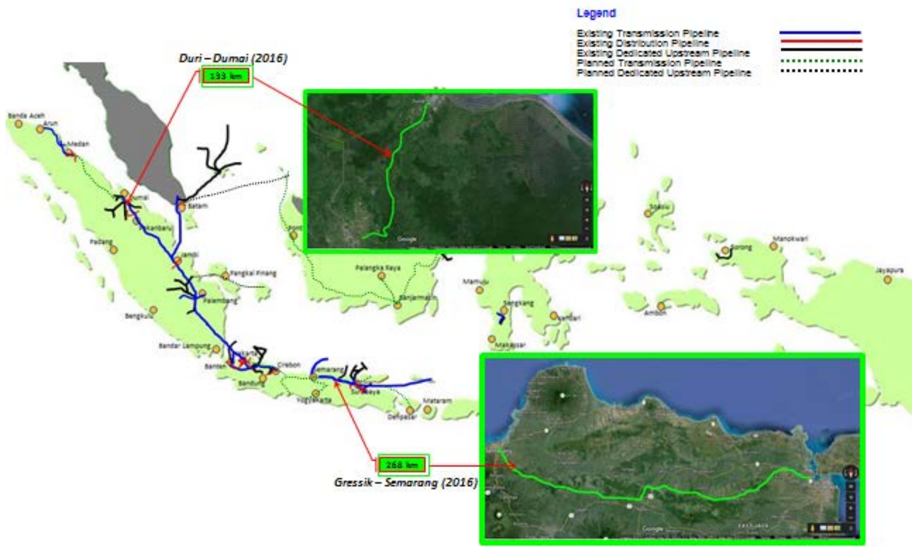

Figure 5.5 Gas Pipeline Roadmap 2016

Table 5.12 GSSI for five regions

Region		Supply		Demand		GSSI
		Domestic	Import	Domestic	Export	
		mmscfd	mmscfd	mmscfd	mmscfd	
I	NAD and Sumatera Bagian Utara	64	80	181	0,00	0,78
II	Sumselteng, Kepri, Jabar	3171	220,00	2067	1026,00	0,69
III	Jawa Bagian Tengah, Jawa Bagian Timur and Bali	741,6	0	661	0	0,46
IV	Kalimantan Bagian Timur	1998	0	684	944	0,58
V	Papua, Sulawesi Selatan, Sulawesi Tengah and Masela	1577	0	538,5	838	0,35

5.5. Analysis and Policy Implications

5.4.1 Analysis

In this paper, the GSSI was first calculated for nine Indonesian gas market regions:

1. NAD
2. Sumatera Bagian Utara
3. Sumatera Bagian Tengah dan Selatan
4. Kepulauan Riau
5. Jawa Bagian Barat
6. Jawa Bagian Tengah
7. Jawa Timur dan Bali
8. Kalimantan Timur
9. Sulawesi Tengah, Selatan, Papua dan Masela.

The results show that Kalimantan Timur, NAD and Kepulauan Riau and Jawa Bagian Barat have the four highest score which means these regions are the most vulnerable in terms of gas supply disruption. Kalimantan Timur is the most vulnerable region followed by NAD, Kepulauan Riau and Jawa Bagian Barat. On the other hand, Sulawesi Tengah, Selatan, Papua and Masela is the least vulnerable region.

The vulnerability of Kalimantan Timur region can be explained from its high gas intensity of RGDP. It scored the highest among other regions. This high G_1means higher gas consumption for increasing one unit of RGDP, this results in larger adjustments costs and impacts on gas supply security in the event of natural gas supply shocks. In addition, it also scores second highest in terms of the share of imported gas in total energy demand (G_2) which put this region more vulnerable to regional gas developments, where in this case gas supply deficit in this region is less likely to be supplied from other region if no gas infrastructure build to connect this region and other region. The strength of this region is itshigh value for $G_{3,}$ means that Kalimantan Timur region is a less vulnerable or more secure to supply shocks compared with other region in the study since this region is a major gas producer in Indonesia.

Most of gas produced in Kalimantan Bagian Timur region goes to meet industrial demand (fertilizer and petrochemical) and electricity demand, with the biggest part goes to Bontang LNG Terminal to be exported to other regions (NAD, Sumatera Bagian Utara and JawaBagian Barat), and abroad i.e Japan, Korea and Taiwan.

Nangroe Aceh Darusalam is the second most vulnerable region. It has similar scores for G_1 and G_2 with Kalimantan Bagian Timur but in contrary has one of the lowest score in G_3which reflect this region vulnerability due to its declining gas production.Total demand in NAD region is higher than the existing supply hence there is a gas deficit. To anticipate this deficit, the Regasification Terminal has been constructed, converted from a LNG Terminal in the past. Currently this region imported 80 MMSCFD gas from Kalimantan Bagian Timur.

Kepulauan Riau is the third most vulnerable region mostly because its very high G2 score. It is almost three times higher than that of Kalimantan bagian Timur. This is due to huge deficit in 2014 compared to low total primary energy consumption in this ales populated area. In 2014 it exports contract volume was 658 mmscfd to Singapore, compared to 82 mmscfd domestic demand, despite its low production of 544 mmscfd, so there was a relatively big deficit of gas supply.

Jawa Barat is the most industrialized region in Indonesia. Its gas demand in 2014 was 1534 mmscfd compared to its domestic supply 6444 mmscfd. This make this region's score for G_2 is the highest due to high net imported gas consumption compared to total primary energy supply. While the score for G_1 and G_3 are relatively low.

This region imports gas from Kalimantan bagian Timur and Sumselteng. This make Jawa Bagian Barat the fourth most vulnerable region in Indonesia. Gas consumers in this region are fertilizer plant, electricity plants, industry, transportation, and city gas.

Sumatera Bagian Utara, Jawa Bagian Tengah have similar scores 0.58 to 0.57 respectively. They are characterized by medium domestic production and higher demand hence experienced deficit/gas import.

Kelulauan Riau and Papua topped the GSSI list with 0.14 and 0.49 respectively. Both regions with no deficit/import and small domestic gas consumption compared to their productions make them have low G_2 and high G_3.

In the proposed new regions, we combined region NAD and Sumatera Bagian Utara, Kepulauan Riau with Sumselteng and Jawa Bagian Barat. There are new pipline that connected NAD and Sumatera Bagian Utara as well as new LNG regasification Terminal in NAD. On the other hand, the existing advanced pipeline network (transmission, distribution)between Sumselteng and Jawa bagian Barat are now connected to two LNG regasification terminal, one in Jawa Bagian Barat, and the other one in Sumselteng to ensure stable supply of gas to this region.

Table 5.9 shows the results for new six regions. The new connected regions are now ranked second and third most secure regions. NAD and Sumatera Bagian Utara now have low G_1 score therefore it is less vulnerable to gas supply disruption on their economy since they have more access and supply from the pipeline and from the new LNG regasification terminal.

Sumselteng, Kepulauan Riau and Jawa Barat Region also have a significant improvement. Now they rank better in terms of security of supply since they are now regarded as one region with more interconnectivity and potential supply from other region through the two LNG regasification terminal. Although the latter makes this region G_2 score high (net imported gas consumption to total primary energy supply ratio) but their relatively high G_3 and G_1score help this region to have a better GSSI index.

5.4.2. Sensitivity Analysis

There are two sensitivity analysis made, first it by assuming there are LNG Terminal and Regasification unit ready in several regions which allowed them to import gas from abroad. The second one is by assuming the new gas pipeline network connect Region Jawa Bagian Tengah and Jawa Bagian Timur and Bali, hence they can be considered as one region. The result shows that for the nine regions category, all of the regions' GSSI score are improved, except for Kepulauan Riau Region. Kepulauan Riau gas demand is 740 MMSCFD while their production is only 544 MMSCFD, hence they need to import 196 MMSCFD. This makes their net gas import dependency score jumps from zero to 21, the highest among other regions. On the other hand, in the six regions category where Kepulauan Riau is grouped with Sumatera Bagian Selatan and Jawa Barat, where they are connected by gas pipeline network, they have the second best score (second less vulnerable) after Papua, Sulawesi Selatan, Sulawes Tengah dan Masela.

The second sensitivity analysis is by combining Jawa Tengah Region and Jawa Timur and Bali Region since according to the government plan, they are going to be connected by pipeline in 2016.

The result shows that the GSSI score of this new region increases from 0.58 and 0.53 respectively to 0.46 after they grouped together. This is because some producing fields in both regions can now supply both regions using the pipeline network.

5.4.2 Policy Implications

Since Indonesia is an archipelagic country, gas transportation between islands is facing quite a big challenge. Only until 2012 the country first Natural Gas Regasification Unit was built and operated. This can solve problems of transporting gas from remote and less developed region to more industrialized region to meet the demand.

The development of more integrated gas pipeline network that connect several neighboring yet isolated region should be another key to boost natural gas distribution among regions.

To test effectiveness of this policy, this study tries to test the GSSI by combining regions into six regions with more connected region based on available infrastructures. The results shown that two new regions: NAD & Sumatera Utara (Region I) and Sumatera Bagian Tengah, Selatan, Kepulauan Riau and Jawa Barat (Region II) perform better compared to region that are not combined such as Jawa Tengah (Region III) and Jawa Timur & Bali (Region IV).

This result support the government planning to build more regasification unit to increase connectivity between islands and more extensive gas pipeline inland to secure more secure gas distribution. For example by connecting Jawa Tengah (Region III) with Sumatera Bagian Tengah, Selatan, Kepulauan Riau and Jawa Barat (Region II) and Kalimantan Timur (Region V) into one by pipelines as has been planned but yet to realized, as seen on Figure 5.4 below.

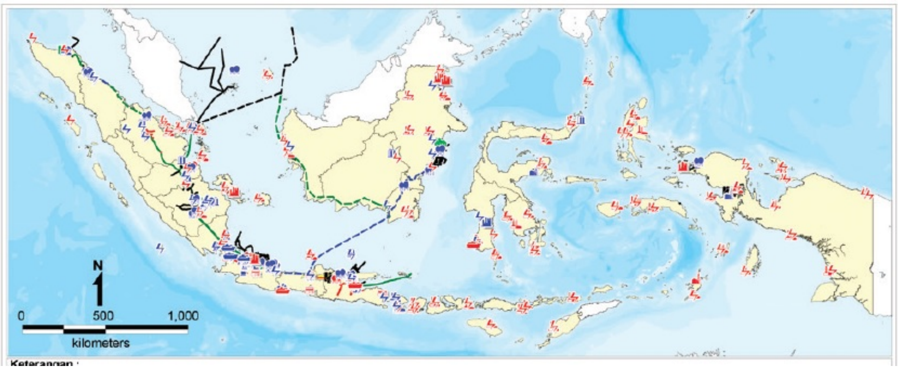

Figure 5.6 Existing and Planned Gas Infrastructures (MEMRa, 2015)

6. General Summary

This dissertation consists of three essays. The first one is a qualitative essay, which discusses an overview of Indonesia’s energy security situation by presenting the current energy policy framework, energy scenarios, and energy security indicators to show that the task to secure a sufficient energy supply will become even more challenging. This qualitative essay provides a basis for the other two quantitative essays. The first quantitative essay evaluates Indonesia’s energy security by using an index method. It considers all types of energy resources to be calculated in order to get the historical energy security index from 2000 to 2012, and to get a better view on Indonesia’s energy security policy measures over the specified period of time. The second qualitative essay evaluates the gas supply security index of Indonesia based on the country’s gas market regions, as stated in Indonesia Gas Balance 2015-2030 (2015).

Indonesia’s energy needs are growing along with its economic growth. As shown in Chapter 3, Indonesia’s energy consumption still depends on non-renewable sources of energy, such as crude oil, coal, and natural gas. Natural gas is more reliable than oil in terms of availability because gas resources have not been developed to the same extent as oil resources, and they are more widely distributed. Non-conventional gas resources are also abundant. Conventional oil, although depleting, will remain an important energy source where a significant non-conventional oil resource could become part of the reserve base in the future. Coal will still have a large share in the energy mix in the future, as its estimated reserves are large where the R/P ratio is 75 years. Due to the natural depletion of fossil fuel reserves, as well as the negative effects of greenhouse gas emission, sustainable and renewable energy development is necessary.

However, renewable energy share in power generation is approximately 3%. Considering Indonesia's natural condition and geography, it has great potential for renewable energy, such as solar, wind, micro hydro, and biomass energies. Hence, the government must pay more attention to the renewable energy utilization.

The NRE and hydro energy are affordable on a local scale, but not as a major energy supply resource. They are sufficient enough to cover the current primary energy consumption despite its specific physical constraints, such as weather dependence and low energy supply density.

Similarly, biofuels have supply capacity constraints; therefore, their potential role as a substitute for conventional fuels is limited. Further technology development will help reduce these limitations in the future.

Based on this condition in Chapter 4, we evaluate energy security performance of Indonesia between 2000 and 2012 using the index method. Since the early 2000s, energy security has been a priority of the government of Indonesia. The Ministry of Energy and Mineral Resources defines its first priority as ensuring energy security and independence with emphasis on the domestic supply of energy sources.

This focus is reflected in the Presidential Decree No. 5/2006 on National Energy Policy and Law No. 30/2007 on Energy, in which self-sufficiency and diversification of fossil energy are the main priorities. This is a reasonable option due to Indonesia's abundance of coal and gas. Concern over the environmental dimension, such as CO_2 emission, remains rather low because the biggest contributor to Indonesia's CO_2 emissions is the forestry sector. However, the regional and international pressure on this issue is increasing.

The issue of energy security became even more complex in 2003-2004. For the first time in several decades, particularly in the late 2000s, Indonesia became a net importer of oil with the emergence of climate change issues. Flowing from production decline, Indonesian crude oil exports have also declined as the government decided to prioritize domestic crude oil consumption over exports. As a result, Indonesia enacted the Presidential Decree No. 5/2006 on National Energy Policy in 2006. It is a policy that explicitly pushes the country to reduce its reliance on crude oil and seek other energy sources. However, the country decided to withdraw from the Organization of the Petroleum Exporting Countries (OPEC) in 2008.

This study shows that the policy toward reducing energy consumption through energy subsidy elimination should be given more priority, as it is shown from the result that the affordability dimensions actually have positive trends instead of the energy subsidy reduction between 2000 and 2012. The policy, which improves the diversification of primary energy supply, can also affect the energy security performance positively. This explains the

Presidential Decree No. 5/2006, which mandates to shift away from oil and increase coal and natural gas consumption.

This provides the basis for the second quantitative essay in Chapter 5. This chapter evaluates the gas supply security index of Indonesia's gas regions. The policy to utilize more gas domestically should be supported by the availability of gas infrastructures in order to allow transporting gas from remote areas to gas consuming regions. Based on this essay, it is found that the gas security of supply index from the six regions of Indonesia is still vulnerable to gas supply disruption due to the lack of gas infrastructures, such as gas pipelines network and LNG Terminal/Regasification Terminal to allow gas transportation among Indonesia's islands.

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요약

인도네시아공화국의 에너지안보에 대한 두가지 에세이

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에너지안보는 에너지정책학적 측면에서 상당한 대중성을 얻고 있는 개념이다. 정책입안자, 학계 또한 기업인들이 에너지시장에서의 변화를 제안하거나 이행시 안보의 개념을 논한다. 에너지안보의 개념은 높은 에너지가격, 지리적으로 편재된 자원에 대한 수요증가와 경쟁, 자원의 희소성 및 고갈, 또한 기후변화협약의 영향 등과 같은 복잡한 요인들 추가로 고려하면서 많은 나라에서 에너지정책의 중요한 목표가 되었다.

그러나 에너지정책에서의 중요성에도 불구하고 에너지안보는 아직까지 명확하게 정의되어있지 못하였다. 또한 에너지안보에 관한 공통적인 해석도 없다. 에너지안보는 이러한 다의성(polysemic) 및 다면적 특성으로 인하여 평가하기 까다롭다. 이로 인하여 대부분의 연구들은 가용성 및 경제성과 같은 다양한 요소들을 함께 고려하여 에너지안보를 평가한다.

본 논문에서는 인도네시아의 에너지정책에 활용하기에 적절한 에너지안보의 개념과 의미 및 중요성에 대하여 연구하며, 이를 명확히 하며 인도네시아 에너지산업을 육성하기 위한 전략 또는 정책에 대하여 논의한다. 인도네시아의 경우, 에너지에 대한 수요는 빠른 경제성장으로 인해 증가해 왔다. 에너지자원의 가용성, 접근성 또는 경제성과 같은 요소들은 적절한 에너지 믹스의 구성 및 명확하고 포괄적인 에너지정책 전략과 구조를 마련하는데 중요한 요소들이다. 따라서, 에너지안보에 대한 매우 포괄적인 추정은 정책입안자들이 더 나은 정책결정을 내리는데 도움이 될 것이다.

본 논문의 첫 부분에서는 인도네시아 경제에서의 에너지의 중요성을 예시로 들고, 에너지분야의 특징들이 이 에너지안보 문제에 대한 관심의 증가를 어떠한 방식으로 설명하는지 강조하였다. 두번째 부분에서는 2000~2012 년 자료들에 지수법을 사용하여 분석하였다. 마지막 부분에서는 Indonesia Gas Balance 자료들을 바탕으로 인도네시아의 가스시장의 Gas Supply Security Index 를 평가하였으며 분석 및 정책시사점으로 논문을 마무리 하였다. 본 논문은 인도네시아의 사례를

활용하여, 개별국가의 필요성에 의하여 작성되는 에너지안보 지수의 추정에 대한 이해력을 높이는데 기여하였다.

주요어: 에너지안보,에너지안보지수, 정책분석, 인도네시아

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