EXPLORING THE RATIONALE BEHIND THE STRATEGIC ROLE OF NATURAL GAS IN CHINESE ENERGY POLICY MAKING

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EXPLORING THE RATIONALE BEHIND THE STRATEGIC ROLE OF NATURAL GAS IN CHIENESE ENERGY POLICY MAKING

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This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Arts.

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ABSTRACT

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It is recognized that, indeed, population and economic growth are the crucial actors with regard to energy consumption and production of the countries. As China is the most populous country and a fastest-growing economy, it became world's largest energy consumer and producer country that makes it exceedingly influential country in world energy markets. Until 1993, China was the self-sufficient country based on energy resources, which means that its energy production fulfilled its national consumption. However, Chinese economic growth causes increasing energy demand in the country and it starts to import energy resources from other countries. Historically, the primary energy

resource of China is coal that has 67, 4% of total energy consumption of China by 2013. In spite of the fact that China has huge coal reserves, it needs to import coal after 2009 because of the negative impacts of coal combustion. As a result of high coal consumption, China becomes the leading CO_2 emitter country in the world, due to the fact that it needs to be diversify coal resources with natural gas which is more environment-friendly among fossil fuels. Energy security is the main target of new energy policy of China that has five basic dimensions including; *(1) Availability, (2) Affordability, (3) Accessibility, (4) Acceptability, and (5) Diversification*. China prepares its energy security strategy as a new policy in 12th Five Year Plan that includes increasing natural gas share in Chinese energy mix by 10% by 2020. In the consideration of new energy policy of China, the main aims of this thesis are to examine and analyze the reasons of increasing the share of natural gas in its energy mix and the possible impacts of this demand for the future Chinese energy security and global gas trade from the perspective of energy security.

Keywords: China, Energy Security, Population, Economic Growth, Natural Gas, Coal, Consumption, Production

ÖZET

ÇİN'İN ENERJİ POLİTİKASINDA DOĞALGAZIN STRATEJİK ROLÜNÜN RASYONEL KEŞFİ

SOYTEKİN, Özge

Sürdürülebilir Enerji Yüksek Lisans Programı,

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Nüfus ve ekonomik büyüme ülkelerin enerji tüketimi ve üretimi açısından önemli aktörler olarak kabul edilmektedir. Çin en kalabalık nüfuslu ülke ve en fazla hızla büyüyen ekonomiye sahip ülke olduğu için, dünyanın en fazla enerji üreten ve tüketen ülkesi olmuştur ve bu durum dünya enerji piyasalarında da son derece etkili bir ülke olmasını sağlamaktadır. 1993 yılına kadar, Çin enerji kaynaklarına dayalı olarak kendi kendine

yeten bir ülke olmuştur, bu demek oluyor ki Çin'deki enerji üretimi ulusal tüketimi karşılamaktaydı. Ancak, Çin'deki ekonomik büyüme ülkedeki enerji talebinin artmasına neden oldu ve diğer ülkelerden enerji kaynakları ithal etmeye başladı. Tarihsel olarak, Çin'in birincil enerji kaynağı 2013 yılında toplam enerji tüketiminin %67,4'e sahip olan kömürdür. Çin büyük kömür rezervlerine sahip olmasına rağmen, kömürün yanmasından ortaya çıkan olumsuz etkilerden dolayı, 2009 yılından sonra kömür ithal etmeye ihtiyaç duydu. Yüksek kömür tüketimi sonucunda, Çin dünyadaki önde gelen karbondioksit yayıcı ülke olmuştur. Bundan dolayı, kömür kaynaklarını fosil yakıtlar arasında daha fazla çevre dostu olan doğalgaz ile çeşitlendirmesi gerekmektedir. Enerji güvenliği Çin'in yeni enerji politikasının temel hedefi olup beş temel boyuta sahiptir. Bunlar sırasıyla (1) Elverişlilik (2) Karşılanabilirlik, (3) Erişilebilirlik, (4) Kabul edilebilirlik ve (5) Çeşitlendirme. Çin yeni bir politika olarak 12. Beş Yıllık Plan içerisinde enerji güvenliği stratejisi hazırlıyor, bu plan 2020 yılına kadar % 10 oranında Çin'in tüm enerji kaynakları arasında doğal gazın payının artmasını içermektedir. Çin 'in yeni enerji politikasının ışığı altında, bu tezin ana amaçları Çin'in tüm enerji kaynakları arasında doğal gazın payının artmasının nedenlerini, gelecekteki Çin enerji güvenliği için bu talebin olası etkilerini ve enerji güvenliği açısından küresel gaz ticaretini incelemek ve analiz etmektir.

Anahtar Kelimeler: Çin, Enerji Güvenliği, Nüfus, Ekonomik Büyüme, Doğalgaz, Kömür, Tüketim, Üretim

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CHAPTER 1

INTRODUCTION

China has the largest population in the world with 1,36 billion people that represents 19,8% of world's total population in 2013 since the population of the world is 7,2 billion which means that one of every five people lives in China. After 1980, population of China was over one billion which gave the first position, among other countries, with a population over 1 billion but at the same time, the world's population was approximately 4,5 billion people in 2013. With reference to U.S Census Bureau (2014), the world population has increased between 1959 and 1999 from 3 billion to 6 billion, while Chinese population has increased from 650 million to 1,26 billion within the same years, which means that the population of China has increased with the rate level as the world population. After 2000, the growth rate of world population has started to decrease from 1,3 to 1,2, and moreover,

Chinese population growth rate has decreased from 0,8 to 0,5 between the years of 2000 and 2013 (World Bank, 2013). By 2025, it is expected that the world population will be 8.1 billion and by 2050, the world population will be increased to 9.6 billion with 0,51 growth rate (United Nations, 2014). In the meantime the world population is expected to be 9,6 billion people in 2050, whereas the estimation on the population of China will remain unchanged as 1,3 billion that makes China the second populous country in the world after India with 1,6 billion people by 2050 (Vn, 2013).

The economic growth of China has begun in 1997 after the shift in the economic policies of Chinese government that led to a development in private enterprises of China. Trade liberalization and privatization period in China has led to an increase in Gross Domestic Product (GDP) and economic growth after 1997 (Zhu, 2012). According to World Bank (2013), the GDP of China was 1.4 trillion US dollars in 2003 and it was over 2.2 trillion dollars after 2006, while the world GDP increased from 43 US trillion dollars to 50,4 trillion dollars at the same time. In 2013, Chinese GDP increased to 9,2 US trillion dollars while the world GDP has risen to 77,6 trillion dollars. Moreover, GDP per capita of China is also increasing after the privatization period, though Chinese GDP per capita was 949 Dollars in 2000, but it has risen to 6,807 dollars by 2014 as a result of the new government policy in the country (World Bank, 2013).

The new government policy is in terms of 12th Five Year Plan;

- A 16 percent reduction in energy intensity (energy consumption per unit of GDP);
- Increasing non-fossil energy to 11.4 percent of total energy use; and
- A 17 percent reduction in carbon intensity (carbon emissions per unit of GDP).
- Gas consumption rising from 108 Bcm in 2010 to 230 Bcm in 2015;

- Domestic gas production rising from 95 Bcm to 176 Bcm – 138.5 Bcm from conventional sources, 15-18 Bcm from coal gasification, 16 Bcm from coal-bed methane, and 6.5 Bcm from shale gas;
- Gas imports rising from just 17 Bcm to 93.5 Bcm;
- Installed capacity of gas-fired power stations growing from 26.4 GW to 56 GW;
- The addition of 44,000 km of gas transmission pipelines to the 40,000 km available in 2010; and
- The addition of 22 Bcm of underground storage capacity to the 1.8 Bcm available in 2010.

On the basis of World Bank data (2013), Chinese population was 1,26 billion with 949 dollars GDP per capita in 2000, while it only rises to 1,36 billion but with much more GDP per capita as 6,807 dollars by 2013. Thus, these data show that China has experienced economic development because of the change in government policy since private enterprises make foreign business investment, trades, import and export (Zhu, 2012). Furthermore, China has the second largest economy in the world with the largest primary energy demand, and the economic growth is expected to increase to threefold from 2013 to 2020 (Ren and Sovacool, 2014).

As a consequence of high population along with a rapidly growing economy in recent years, the energy usage has doubled which has made it the largest energy consumer and producer country in the world (EIA, 2014). Until 1993, China was a self-sufficient country based on energy resources which means that its production fulfilled its national consumption. However, Chinese economic growth has caused increasing energy demand in the country that also affects volume of import of energy resources from other countries

(Bambawale and Sovacool, 2010). The total energy consumption of China is 2,85 billion tons of oil equivalent to 22,4% of world total consumption which is 127,3 billion tons of oil (BP, 2013). Additionally, primary energy consumption per capita of China is 1956,8 kg oil since the world energy consumption per capita is lower than China as 1890,4 kg oil by 2011 (EIA, 2014). Coal is the primary energy resource of Chinese energy consumption with 69%; also China is the largest coal producer and consumer in comparison to world's consumption, since it constitutes the half of the coal consumption in the world together with owning the third largest proved coal reserves (EIA, 2014). At the end of 1990s, coal consumption was 672 Mtoe, likewise the production amount; consumption has also increased more than two times in two decades by 1,925 Mtoe in 2013 (BP, 2014). As a result of this, coal consumption has the highest share as three fourths of CO2 emissions of China. Besides, electricity is produced by fossil fuels, mostly from coal, as 65 % of electricity production that causes to decrease share of coal consumption in Chinese energy mix (European Commission Report, 2013). As result of being the largest energy consumer in the world, China is also the largest carbon dioxide emitter country in the world with 9,52 billion tones carbon dioxide that represents the 27,1% of world total emission as 35 billion tones carbon dioxide emission. In 1980, China was the second largest CO2 emitter country with 1,5 billion tones CO2 after United States of 5,15 billion CO2. China has exceeded the United States by 6,75 billion CO2 emissions in 2008 which makes it the largest CO2 emitter country in the world (BP, 2014). Nevertheless, China has to decrease its CO2 emission rate due to reaction of other world countries under the Kyoto Protocol - the agreement signed by China in 1998 to reduce greenhouse gas emissions - since it causes air pollution and health problems (Shuoand Myllyvirta, 2014). According to Wong (2014),

President Xi Jinping said that "China would break the rapid rise in its carbon dioxide emissions, so that they peak "around 2030" and then remain steady or begin to decline. And by then, he promised, 20% of China's energy will be renewable". If China includes decreasing or controlling coal consumption policies in its 13th five years plan, 1,3 billion tons of CO2 emission reduction can be realized until 2020 (Shuo and Myllyvirta, 2014). In the recent years, Chinese government revised energy policy of the country to decrease carbon emission due to coal combustion. Because of that, Chinese government realizes that natural gas is the best solution both environmentally and politically for the reduction in carbon emission. Environmental aspect is not the only reason to increase natural gas share instead of coal. Extremely increasing coal consumption that causes import coal from other countries, diversification against emerging threats of energy security of China and already constructed natural gas infrastructures are the other internal reasons for increasing the share of natural gas consumption in Chinese energy mix (Yao and Chang, 2014).

Hence, there are two main aims of this study. First one is to determine the reasons why China has decided to increase the share of natural gas in its energy mix. Second one is to investigate the possible impact of natural gas demand for the future Chinese energy security and global gas trade. Together with these aims, the following research questions will be answered in this thesis, as follows:

i) What is the rationale behind increasing natural gas consumption in Chinese energy mix?

ii) What would be impact of increasing natural gas consumption on Chinese foreign policy making, especially towards the supplier countries?

iii) How could China secure its additional natural gas supply? Via piped gas or LNG or both?

iv) What are the possible implications of new Chinese policy, considering the environment and the globe?

The study consists of 5 chapters**. Chapter 1** is the Introduction chapter. This chapter briefly analyzes China, including population, GDP per capita, energy issues, environmental aspect (CO2 emission) while comparing past and recent data.

Chapter 2 is the Literature Review. This chapter examines several concepts of Energy Security as its definition is vague, identifying five dimensions, namely (1) Availability, (2) Affordability, (3) Accessibility, (4) Acceptability, and (5) Diversification (4A+D) with the intention of clarifying changing energy policy of China.

Chapter 3 demonstrates Chinese energy profile, including; oil, coal, natural gas, renewables (solar, wind, hydropower, biomass and geothermal), and nuclear energy. Individual energy resources is analyzed in terms of (1) reserves, (2) geographical location, (3) quantity of production, (4) volume of consumption, (5) import and export level and (6) infrastructure.

Chapter 4 discusses the rationale behind increasing natural gas consumption in China. Driving forces are analyzed through two different; (1) internal and (2) external reasons. In addition, possible impact of this shift on local and global energy patterns is examined to show challenges and opportunities for China and the globe.

Chapter 5 is the Analysis & Findings chapter. The main aim of this chapter is to demonstrate the results and findings of this study and to associate them with the above mentioned research questions.

Chapter 6 is the Conclusion chapter that will analyze reasons of increasing the demand of natural gas in its energy mix in consideration of 4A+D dimensions and the possible impact of this demand for the future Chinese energy security.

CHAPTER 2

LITERATURE REVIEW

Energy security is the concept that has variable definitions in terms of different dimensions or elements that are determined by researchers, governments and institutions that have distinct points of view. Although there has been comprehensive agreement about energy security, there is no compromise what it completely should be. Multiplicity on definition of energy security causes to create different elements and dimensions to explain what energy security is (Winzer, 2012). According to Yergin (2006) states that energy security is 'Simply the availability of sufficient supplies at affordable prices, different countries interpret what the concept means for them differently'. He also explains that 'The objective of 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'. Table 1 demonstrates different definition of energy security form different perspectives. This study clarifies what has been energy security before selection of exact concept of energy security.

Table 1: Concepts of Energy Security

	AUTHORS							
	Winzer (2012)	**Kruyt et al. (2009)**	**Sovacool (2013)**	**Ang et al. (2014)**	**Hughes (2009)**	**Karlsson (2010)**	**Lesbirel (2004)**	**Grubb et al. (2006)**
DIMENSIONS	Source of risk	Availability	Availability	Energy Availability	Review	Availability	Security of Demand	Security of Supply
	Scope of impact	Affordability	Affordability	Infrastructure	Reduce	Affordability	Political and Market Disruptions	Diversifi-cation
	Speed of impact	Accessibility	Technology development and Efficiency	Energy Prices	Replace	Accessibility	Diversifica -tion	
	Size of impact	Acceptability	Environmental Sustainability	Environment	Restrict	Acceptability		
	Sustention of impact		Regulation and Governance	Governance		Review		
	Spread of impact			Energy Efficiency		Reduce		
	Singularity of impact					Replace		
	Sureness of impact					Restrict		

While advocating variation of definitions of energy security, Winzer (2012) explains energy security under eight dimensions. These are as follows: (1) sources of risk, (2) scope of the impact measure, (3) speed of threat impacts, (4) size of threat impacts, (4) sustention of threat impacts, (6) spread of threat impacts, (7) singularity of threat impacts, and (8) sureness of threats. Moreover, Winzer describes energy security as conservation from threats that have impacts on energy supply chain. For that reason, the author separates eight dimension of energy security to determine and prevent the threats against security of supply. The source of risk is the first dimension that is divided into three sections as technical, natural and human risk sources. Technical risk sources refer failure of infrastructure component as transmission lines and transformers or power plants. Demand fluctuation, sabotage and terrorism, political instability and geopolitical risks like wars and

export embargo are the examples for human risk sources. Lastly, natural risk sources include the depletion of fossil fuel stocks and natural disasters (Winzer, 2012).

Moreover, while designating threats, the *scope of the impact measure*, *the second dimension*, shows how energy security measured. In that dimension, continuity of commodity like oil, gas and coal and; continuity of service supplies as heating, lighting, communication and transport are affected by fluctuation of availability and price, but also economic continuity that depend on dis-utility of service disruption is also influencing the changes of price and availability of energy services as well. Depletion of energy resource has some impact on human safety and environmental sustainability like nuclear proliferation and water pollution (APERC, 2007).

The *speed of threat impacts* as a *third dimension* of energy security, explains time-scale of long term or short term on which influence of risk realizes. Constant scarcity as renewable energy potential of a country, slow stresses as the depletion of fossil fuels, and fast shocks as political disruptions, are three aspects of particular speed (Stern, 2002). The *fourth dimension* is the *size of threat* that shows significance of changes in scarcity as impending changes; reduced reserve margins, small changes; price volatility, and phase changes; delivery disruptions or global warming (Scheepers et al. 2007). The *sustention of threat impacts* is *the fifth dimension* which refers duration of threat that continuously happens. Threats have three different levels as transitory impact with small interruptions and short-term price volatility, sustained impact with slower speed and fast threats, and permanent impact like the depletion of fossil fuels (Mabro, 2008).

The *sixth dimension* is *spread of threat impacts* which describes geographical aspect divided in three sections; local level refers technical component level that affect individual

household of country, national level indicates failure of export that impact import countries because of political risk, global level emphasize environmental threats such as climate change or solar storms that affects whole countries in the world. The *singularity of threat impacts* is the *seventh dimension* that describes repetition of some unique cases like depletion, anthropogenic climate change and nuclear wars, infrequent cases like political disruptions and natural catastrophes and frequent cases like alterations of wind-speeds (Stern, 2002). The *last* dimension is *sureness of threat* which means uncertainty of risk that can be predicted as fuel depletion, probabilistic as technical failure, and unknown as global warming (Walker et al. 2003).

Kruyt et al. (2009) identify energy security under the *4A dimensions* on which are constituted by Asia Pacific Energy Research Centre (APERC) as a class in 2007. Kruyt et al. (2009) determined four indicators of energy security as *(1) Availability, (2) Affordability, (3) Accessibility and (4) Acceptability* that are called classification scheme. Unlike Winzer (2012), they did not explain whether it is a classification of values or threats. 4A indicators of energy security are explained as follows; *Availability* is related with geological existence of energy resources, which has crucial importance on energy security. Estimation reserves, production data, Reserve-to-production ratios (R/P), depletion of production fields, predicted undiscovered reserves are the several ways to designate availability of energy security (Karlsson, 2010). *Affordability* refers to economical elements of energy security like cost of energy resources or usage, flexibility in prices of energy sources, quantity of money a country spend for energy usage. To provide energy security in terms of affordability indicators, prices of energy and fluctuations on prices of fuels should be low which means that it is the ability for people to pay. Lower cost of

energy production and import is the main reason of low prices on energy (Sovacool and Rafey, 2011). *Accessibility* is the existence of geopolitical elements of energy security that provide the way to access available energy resource. Some resources cannot be accessible in spite of it is availability because of some technical, political, geographical reasons. There has been some constraints to access energy resources such as infrastructure like pipeline or LNG terminals, geographical restrictions as undiscovered resources, geopolitical barriers because of government policy or exercise of market power (APERC, 2007). *Acceptability* refers environmental elements of energy security that are the crucial indicators including different actors such as local population, environmental NGOs and industries. Moreover, environmental factors such as greenhouse gas emission and other pollution factors by the energy use, deforestation and land use, waste from production, production efficiency are taken into attention for the importance of environmental acceptability (Cherp and Jewell, 2014).

Ang et al. (2014) emphasize same concept of energy security in terms of their viewpoint, but not identical in sense of subjects of 4A dimensions, under different names including; *(1) Energy Availability, (2) Energy Prices, (3) Environment, and (4) Governance*. Moreover, they propose two more dimensions as *(5) Infrastructure* and *(6) Efficiency* to explain what energy security is. *Infrastructure* is the stable and uninterrupted energy supply that is transformation facilities, oil refineries and power plants, distribution and transmission facilities as electricity transmission lines, pipelines and energy storage facilities. To have straight infrastructure facilities is the precondition for consistent supply of energy and significant part of energy security. *Energy efficiency* is related with energy intensity, which is required to be low to improve energy security by reducing energy needs.

Improving technologies, practices and systems are the subsidiary elements to decrease the amount of energy.

Concurrently, Sovacool (2013) explains energy security under the dimensions of (1) *Availability, (2) Affordability, (3) Technology development and Efficiency, (4) Environmental Sustainability and (5) Regulation and Governance*. Likewise Kruyt et al. (2009), *Availability* is explained as total primary energy supply of fuels, also consumption and production level of the energy resources, dependency rate of fuels and diversification, and *Affordability* is clarified in terms of economic activities as stability of energy prices such as retail and domestic. *Technology development and efficiency* are the newly referred dimensions which include government expenditures on research and development and energy consumption GDP per capita and transmission and distribution losses of energy resources that cause low energy efficiency. *Environmental sustainability* emphasizes climate change and pollution that occurs because of carbon emission and sulfur dioxide emission and water access availability of the countries, as well as forest area percentage within the total land area of the countries. The last dimension referred as *regulation and governance* includes energy export activities, total government expenditures over energy activities of governments (Sovacool, 2013).

Additionally, Hughes (2009) explains in detail reducing energy usage and intensity under one of the elements of 4R as (1) *Review, (2), Reduce, (3), Replace and (4) Restrict* to describe and analyze energy security. Furthermore, Karlsson (2010) also advocates concept of 4R to achieve energy security together with 4A dimension, which is one of the ways of reviewing energy security. *Review* is explained as the *first element* to define energy security, which means understanding the problems. The state of jurisdiction for energy

sources is qualitative (political) and quantitative (cost and infrastructure) to review on resources suppliers, supplies of energy and infrastructure. Sector examines the energy services and energy intensities like heating and cooling in detail. Potential secure energy supplies should be reviewed, which is available for jurisdiction via analysis of infrastructures and cost of energy (Hughes, 2009). *Reduce* is the use of less energy via energy conservation or energy efficiency or both, which provides energy security. Energy conservation is initialized rapidly and typically with little cost such as decreasing room's temperature, reducing roadway speeds, and turning off unnecessary lighting. Energy reduction takes more time and money rather than conservation such as insulating a building to reduce heat loss, purchasing a vehicle with an improved fuel economy and buying bulb with lower wattage (Karlsson, 2010). *Replace* means that for enabling energy security, replacing new or more secure energy sources is one of the elements. Through diversification of energy supplies and resources or changing the routes or infrastructure, energy is transported in a more secured way. Major economies have executed important replacement programs within the transportation sector to provide security of infrastructure (Hughes, 2009).

Restrict refers limiting new demand to secure sources since replacement indicates the existing demand for energy sources. Industrialization, economic growth and increasing population caused rising demand for new supplies of energy. Restriction of energy source to secure ones can be problematic because of lack of secure energy sources and infrastructure to meet new demand (Karlsson, 2010). Furthermore, Lesbirel (2004) also defines energy security with different concepts including; (1) *Security of Demand, (2) Political and Market Disruptions and (3) Diversification*. Concept of energy security is

negotiable concept because different conceptions can be used in order to explain energy security. The *first* concept of Lesbirel to explain energy security is *security of demand*. It is supported that security of demand has crucial influence as well as security of supply. While enabling energy security for supplier countries, security of demand is the important factor to supply energy resource to the secure country. Therefore, there should not be any obstacle, originated from demander country such as political or market disruption. The *second* concept of energy security is *political and market disruptions*. Both demand and supply sides of energy partners can have political disruption in terms of both internal and external relations. Therefore, countries that makes energy trade among themselves, they are at risk both demand and supply side. However, disruptions can also realize in demand side that affects energy export of supplier country because of the political problems. Moreover, Lesbirel (2004) discuss market disruption as a risk of energy security. Countries which imported energy, have also market trouble as a risk of energy security. Shortage and surplus of energy in the market can occur because of the low or high import volume of the country, because of the fact that country should directly provide demand and supply balance. The *last* concept is *diversification* to enhance energy security by reducing risks of import from one country to another country. It is supported that diversification of suppliers should be the main goal of importer country to reduce risk and to spread dependency over one country. Lesbirel (2004) explains that 'Don't put all your eggs in the one basket'. Dependency to one country increase risk of disruption so importer countries make trade with several countries in order to create competition to decrease energy price and to enable energy security in their countries. Moreover, Vivoda (2009) also supported diversification of routes and diversification of resource in addition to diversification of suppliers. Thus,

diversification of routes and resources are important factors as components of energy security strategy in order to decrease supply risk for importer countries. Energy trader countries should use different routes including pipelines and vessels or different geographical ways. Moreover, diversification of resource plays a key role to reduce resource risk, not being dependent on one resource as fossil fuels in the energy consumption of the country. Moreover, Grub et al. (2006) emphasizes *(1) Security of Supply and (2) Diversification* to explain the concept of energy security. They define *security of supply* in terms of threat of supply security, including failure in primary fuel resources, transmission network problems, generation capacity limitations and operational failures. Likewise, there are many definition of security of supply, there are many threats and concepts of risks. Risks and cost are the fundamental concept of security of supply. Likewise Lesbirel (2004), Grub et al. (2006) also defines diversification as ‘‘don’t put all your eggs in one basket’’. However, they emphasized what the diverse set of basket should be. Energy type, energy resources (geographic region or company), technological knowledge source (by country, sector or company) are the diverse set of the baskets.

With respect to the above-mentioned several definitions or dimensions of energy security, this thesis aims to explain driving forces and effects of increasing natural gas consumption in Chinese energy policy within the perspective of energy security and concept of 4A+D including ; *(1)Availability, (2) Affordability, (3) Accessibility, (4) Acceptability and (5) Diversification*.

Availability dimension of energy security is related with geological elements that are explained with coal reserves to production ratio, oil import dependency and estimation reserve of natural gas in parallel with natural gas consumption for China. Reserves to

production ratio of coal is 31 years for China since China has 114.500 million tones proved reserve (BP Statistical Review, 2014). It means that Chinese coal reserve remains 31 years in relative to its high production of coal in its energy mix. Because of that, in order to have a secured energy policy, it is required to find new alternative resources and sources for China like natural gas while decreasing coal's share in its national energy consumption (EIA, 2014). China is a net oil importer country with 6,2 million barrels per day in 2013, but it is expected to pass United States of America as the largest oil importer country in the world at end of the 2014 (EIA, 2014). Oil is the second largest energy resource in China's energy mix that is consumed for energy usage, but production has not been parallel with rising demand whilst import dependency for oil becomes indispensable (Figure 6 in Chapter 3). There has been insecure energy policy, excessively depending on coal. For this reason, diversification of resources with natural gas is an alternative to enable energy security for its energy mix (IEA, 2014). Natural gas consumption has increased faster than any other fossil fuels in recent years. According to the 12th Five-year Plan projects of China, natural gas consumption will reach 230 bcm in 2015 and 250 millions of people among Chinese population have access to natural gas facilities (China Energy Focus, 2013). According to BP (2014), natural gas reserves of China are 3,3 trillion cubic meters by 2013 and reserve to production ratio of natural gas is 28 years for China which means that increasing natural gas consumption of China cannot be met by Chinese indigenous natural gas resources, thus import of natural gas is required to enable energy security in China. *Affordability* refers to economical elements that are threats to energy security like cost of energy resources or usage, flexibility in prices of energy sources in Chinese energy mix. It is mentioned that coal has the highest share in energy production and consumption of

China, hence, price of coal is crucial factor for industries and households because of having highest share of electricity production by 66% in 2012 (EIA, 2014). However, there has been volatility in electricity prices because of the liberalization in coal energy sector of China. Therefore, it has affected households directly because flexible prices can establish much higher prices that affect both households and industrial sectors (Yao and Chang, 2014). Natural gas is the alternative resource to produce electricity or to be used in heating and cooling with lower prices both for industry and households in China. *Accessibility* defines geopolitical elements of energy security. Most of the coal reserves, approximately 90%, is located in interior parts of China, since eastern part of China has higher demand for energy resources by having more industrial activities and high population (EIA, 2014). Therefore, demand and supply has large transportation distance which causes inefficiency, pollution and waste. Transportation of coal to the end user or industries is very difficult and costly because of the incompatible natural water distribution. Because of that, import of coal is more appropriate, although China has indigenous coal reserves in its territory, since China decides to increase share of natural gas instead of coal (Eels, 2014). Besides, current international natural gas pipelines such as the Central Asian Gas Pipeline (CAGP) from Turkmenistan, Uzbekistan, and Kazakhstan to China and the China-Myanmar gas pipeline, and existing twenty LNG terminals in the urban coastal area are privileged and accessible to import natural gas and LNG in order to diversify coal (EIA, 2014). *Acceptability* emphasizes the environmental aspect of energy security that explains share of CO2 and SO2 emissions of China under commitment of the Kyoto Protocol (Yao and Chang, 2014). According to BP data (2014), carbon dioxide emission of China is 9,5 billion cubic meters that happens to construct 27,1% of world's total CO2 emissions. High coal

production and consumption of China is the crucial factor of having the largest CO2 emissions in the world, which causes air pollution and health problems. In addition, it has the highest population country in the world with 1,357 billion people (BTI, 2014). While coal consumption still constructs significant part of CO2 emissions since three important economic regions Beijing-Tianjin-Hebei (JJJ), Yangtze River Delta (YRD) and Guangdong cut their use of coal by 0,7% in 2013, which occurs 30% share of the total coal consumption in China. Under the commitment of Kyoto protocol, China estimates a reduction in CO2 emissions by 700 million tones via decreasing coal production and consumption to produce energy for electricity, cooling, heating. (Shuo and Myllyvirta, 2014). While decreasing coal consumption for emission reduction, importing natural gas is the one of the alternative to meet energy demand of China. Natural gas is more environmental friendly than other fossil fuels such as coal and oil because of producing less CO2 and SO2 emissions (Yao and Chang, 2014). *Diversification* is defined as ‘‘don’t put all your eggs in one basket’’ which means to diversify *resource, source and routes* from energy security perspective. New energy policy of China required the diversification of resource (fuels), source (suppliers) and routes (way). According to 12th Five Years Plan of China, government decided to increase natural gas share in its energy mix. Diversification of resource is realized by diversifying coal with natural gas. For decreasing CO_2 emission, natural gas is the best option as it is less harmful fuel than coal. Diversification on resource causes to diversify source and routes; when the type of fuel import is changed, they are also changed correspondingly (China Energy Focus, 2013). Diversification of routes led to increase the way of import as piped gas or LNG. The Central Asian Gas Pipeline, carrying Kazakh and Turkmen gas and running also from Uzbekistan,

is also the connection pipeline between Russia and China. The China- Myanmar Gas Pipeline is the second pipeline connection to carry Myanmar natural gas to China. Qatar is the leading LNG importer country of China. Besides Australia, Malaysia and Indonesia are the other important LNG exporter countries (Figure 16 in Chapter 4) Diversification of sources or suppliers in China creates increases in the share of natural gas suppliers as Russia, Kazakhstan, Turkmenistan, Uzbekistan, Myanmar, Qatar, Australia, Indonesia and Malaysia (Figure 17-18 in Chapter 4) (EIA, 2014). (Tang, 2014).

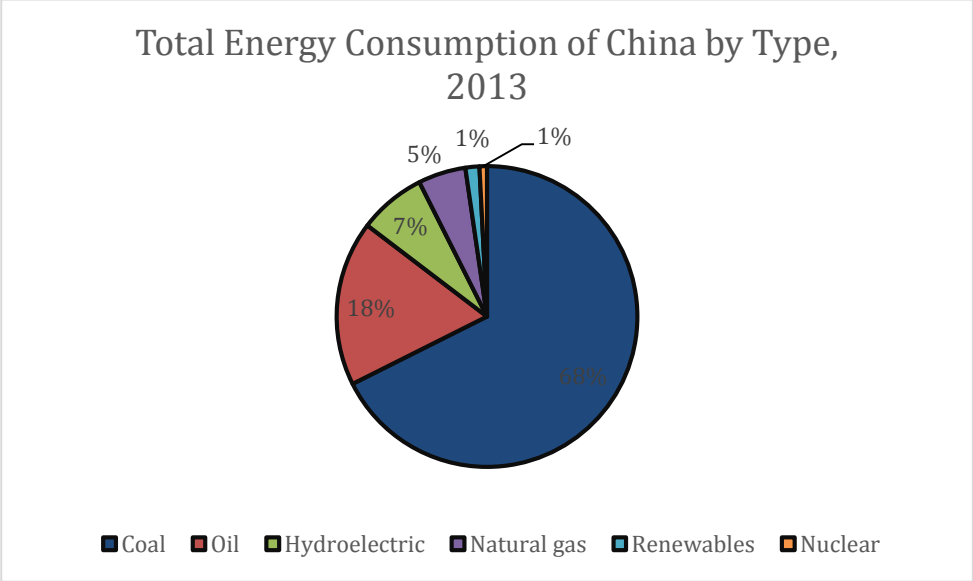
This study analyzes Chinese new energy policy of increasing natural gas share in Chinese energy mix from energy security perspectives under the concept of 4A+D, selected as the exact concept of energy security. The next part of the study will analyze Chinese energy mix in terms of resources including coal, oil natural gas, renewable energy and nuclear energy in consideration of reserves, geographical location, quantity of production, volume of consumption, import and export level and infrastructure.

CHAPTER 3

ANALYSIS OF CHINESE ENERGY MIX BY RESOURCES: COAL, OIL, NATURAL GAS, RENEWABLES AND NUCLEAR ENERGY

China İS the largest energy producer and consumer country in the world because of high population and economic growth caused increasing energy usage. Also, China is the second largest oil consumer country after United States, and became largest oil importer country by 2014 by exceeding United States (EIA, 2014). The primary energy resource of China is coal by 68 % equivalent to 1925 Mtoe that is decreasing year by year in consideration of new energy policy of Chinese government. The second consumption resource is the oil by 18 % equivalent to 507,4 million tones that makes China the second largest oil consumer in the world. Hydroelectric is the third energy resource in China by 7,2% of total energy consumption in 2013 (BP, 2014).

Figure 1: Total Energy Consumption of China by Type



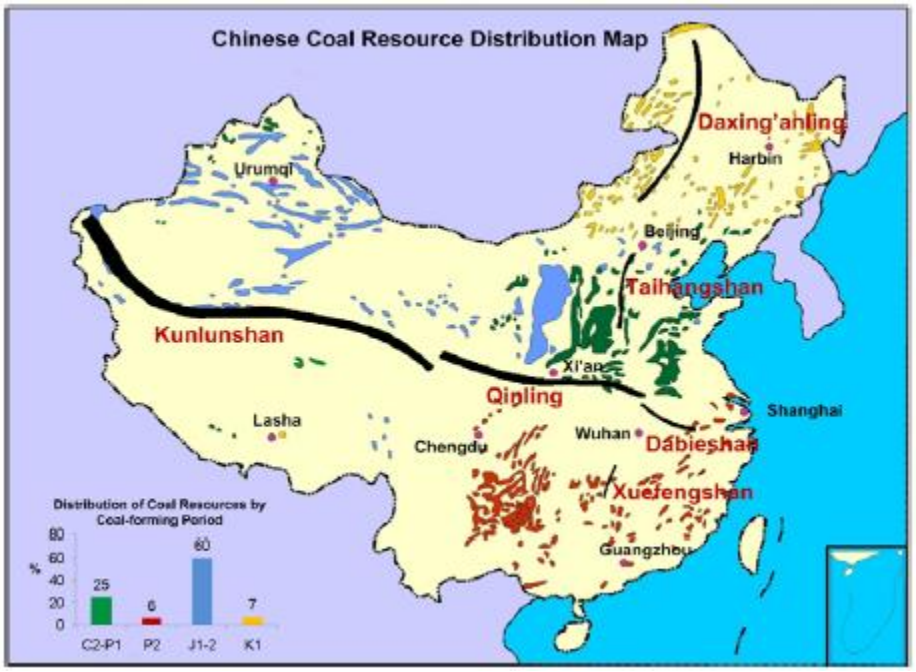
Source: BP, 2014

As shown in Figure 1, natural gas is the fourth energy resource by 5% equivalent to 161,6 bcm that is 3,5 times bigger than Turkey's natural gas consumption by 45,6 bcm (BP, 2014). However, natural gas consumption is increasing in China year by year due to new energy policy of China. Chinese government proposes to decrease coal share to 65% by 2017, 63% by 2020 and 55% by 2040 under the policy of 12th Five Year Plan. Chinese government realizes that although coal has some benefits for Chinese manufacturer sector with huge coal mines, disadvantages such as environmental problems and CO_2 emissions have vital importance (EIA, 2014). Diversification of coal is required to decrease coal consumption; therefore natural gas is the best option both economically and environmentally among fossil fuels. Current natural gas pipelines and LNG terminals are sufficient to import huge amount of natural gas, which is economically advantageous to import natural gas. Also, natural gas has less CO_2 emission and more environment-friendly than coal (Tang, 2014).

3.1. COAL

In the beginning of the 20th century, coal reserves of China have started to decline significantly from 1 trillion tones to 700 billion in the 1950s and 300 billion tones in the 1970s (Aden et al., 2009). In the history, coal has the highest share among energy resources of Chinese energy mix in terms of reserve, production, and consumption. Coal is still the primary energy resource of China since it had been accounted for 73.4% of proven reserves of conventional energy and 94.3% fossil energy with an estimated 114,5 billion tons of proven reserves in 1997 (IEA, 1999). According to World Energy Council (2013), China also has 114, 5 billion tones (or 54,3 thousand Mtoe) recoverable reserves of coal. Coal reserves of China are distributed over 600 km^2 of land area but 90% of these reserves are located in less developed regions of China that are easily susceptible on environment. There are five major districts dividing the Chinese territory of coal reserves, which are northeast China, north China, south China, northwest China, and Tibet Yunnan (Tu, 2013).

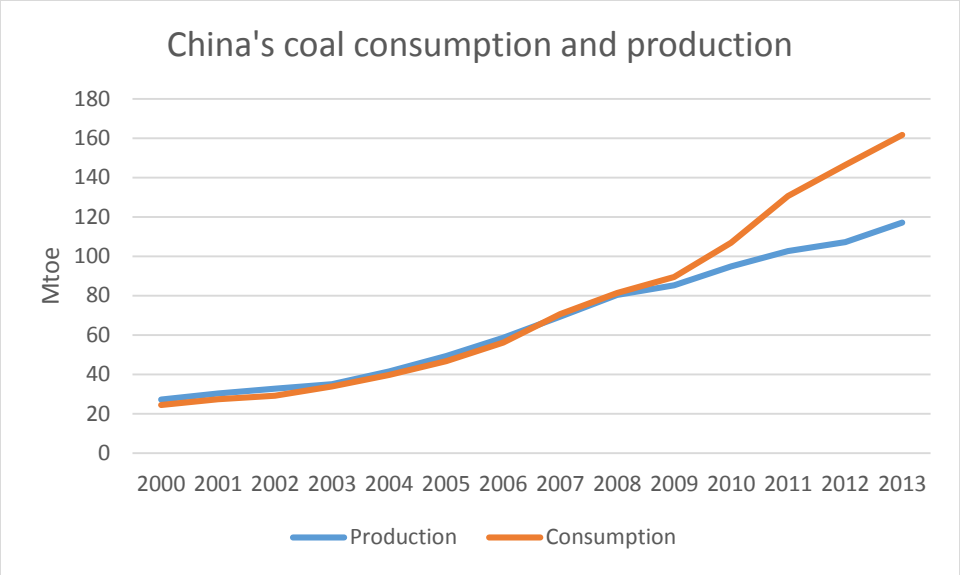
Figure 2: Chinese Coal Resource Distribution Map



Source: Chinese Ministry of Land and Resource

In Figure 2 shows that coal reserve in China is located mostly in the northern region, which accounts for 89% of Chinese total coal reserves. Around 58.5% of northern region's reserves are located in Shanxi, Inner Monolia, Henan and Ningxai in northern China; 11% of reserves are located northern west or Xinjilang region and 8,7% of coal reserves are located in the provinces of Guizhou, Sichuan, and Yunnan in the southern region (Sun, 2010).

Figure 3: China's coal consumption and production



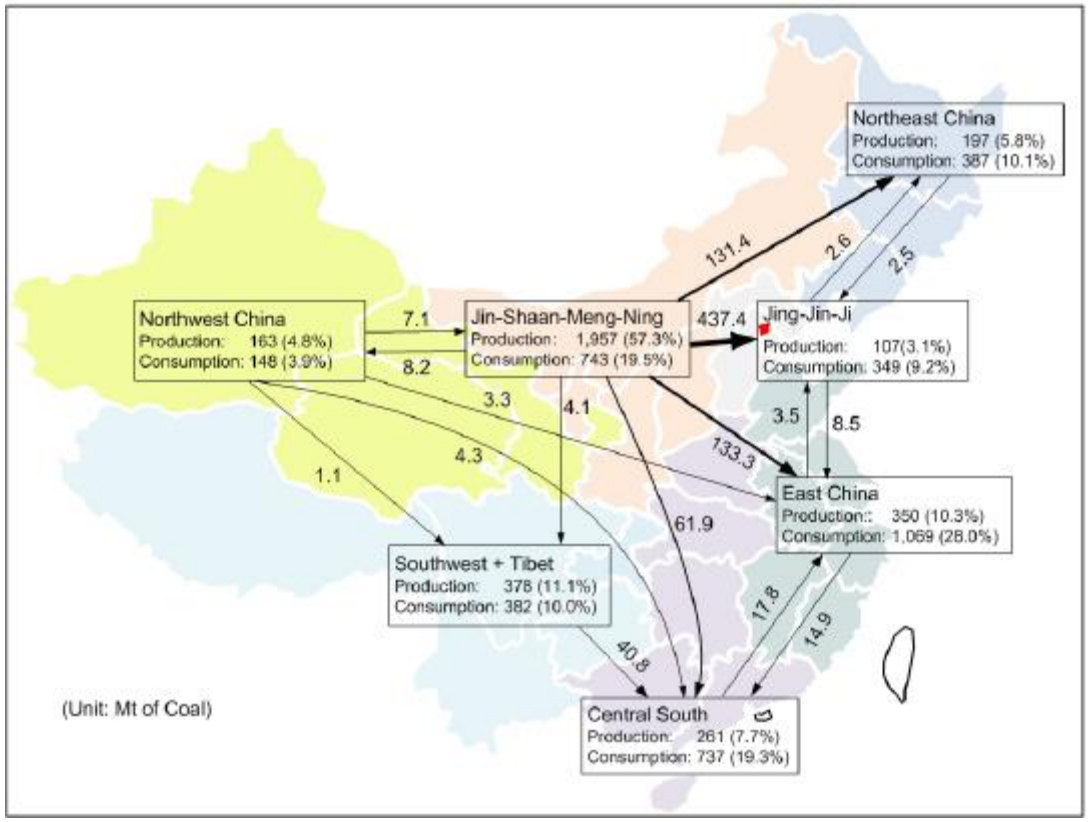
Source: British Petroleum, 2013

China is the largest coal producer and consumer country the world, since it is accounted for half of the coal consumption in the world, ranking with largest third proven coal reserves after United States and Russia (EIA, 2014). Figure 3 demonstrates the coal consumption and production trends in China. In 1999, China Coal Industry Association was founded to act as a bridge between the coal industry, producers and government after the coal market liberalization period (IEA, 1999). At the end of the 1990s, coal production of China was about 682 million tones oil equivalent, but it has increased to threefold in two decades to 1,84 billion tones oil in 2013 (BP, 2014). Shanxi province is the leading production and consumption district in the region by 349 million tones production which is 25% of total production of China, Henan (108 million tons), Sichuan (96 million tons), Shandong (90 million tons), Heilongjiang (82 million tons), Hebei (82 million tons) and Inner Mongolia (73 million tons) follow the Shanxi province in coal production (Sun,

2010). In the thirteen district of coal reserves, there are three types of coal mines which can be classified in terms of their quality of output of coal including; bituminous coal that is the highest quality and much produced coal type by 76% of total production; anthracite coal that follows bituminous coal by 20% production, and lignite & brown coal follows by 4% production with lower quality (Aden et al, 2009). At the end of 1990s, coal consumption was 672 Mtoe, likewise the production amount; consumption has also increased more than two times in two decades by 1925 Mtoe in 2013 (BP, 2014). Demand growth of coal is decreased because of the government policy of China, but the three leading consumer provinces of China that are Xinjilang, Qinghai, and Shanxhi have been increasing their demand as well as increasing the amount of production. Whilst power generation has the largest share in the coal consumption with 50%, the rest of the consumption is distributed between other sectors as metal processing with 16%, heating with 5%, manufacturing with 7%, residential with 5%, cement industry with 8%, energy sector use with 4%, commercial and agriculture uses with 2% and others with 5% (Sussams, 2014).

Until 2009, China was a self-sufficient country in coal consumption; however, although China has coal reserve, coal production of China could not meet coal consumption of the country. Also, China was net coal exporter country in the history; it has begun to import coal from Indonesia and Australia which accounts for 60% of its coal imports, makes China the second largest importer after Japan (Wang et al, 2013).

Figure 4: China's Inter-Regional Coal Flow by Rail



Source: Ministry of Transportation and Communications, Ministry of Railways and China Coal Transport and Distribution.

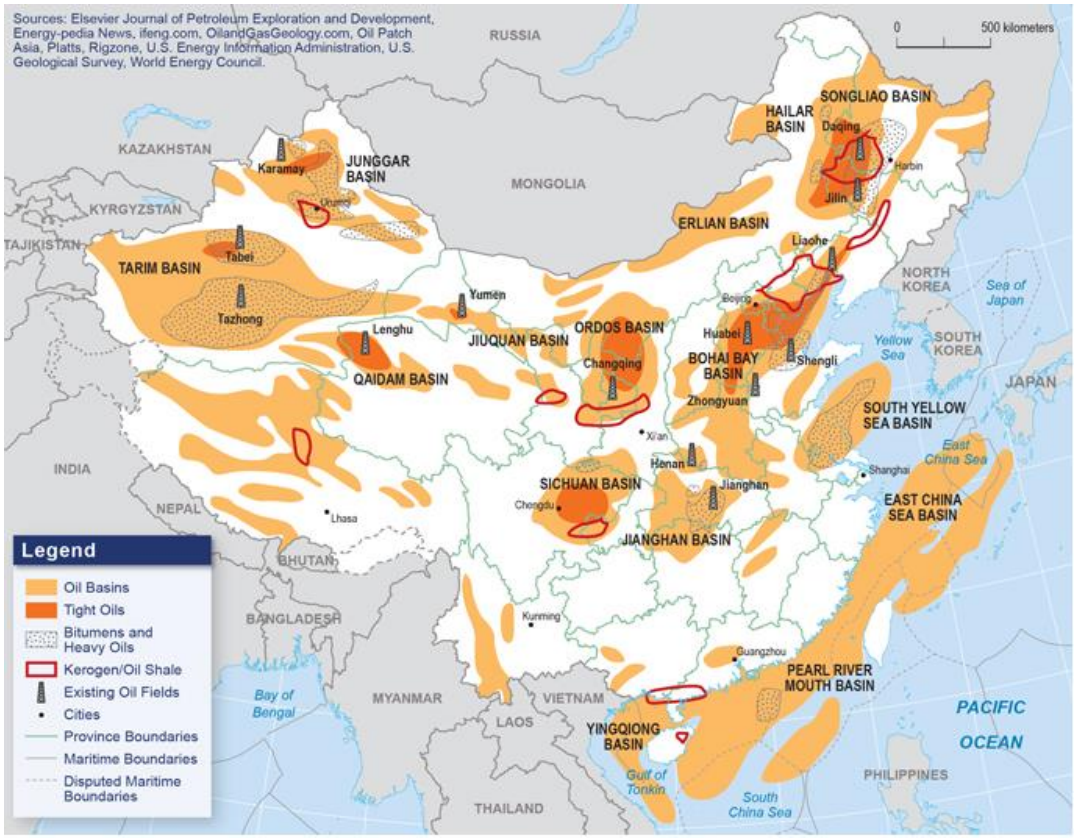
In Figure 4 shows the railway flow to carry coal from supply regions to the market in coastal region. Long distance between energy supply and demand regions of China causes struggles to transport coal resources and creates increased transportation cost of carrying from west and north to southern and eastern provinces of China. Whilst consumption on coal was increasing year by year, importing coal became an alternative to be more competitive and low price for coastal region of China in comparison to Chinese local coal production (EIA, 2014). South Korea, India, Australia, Indonesia and Germany are coal

exporter country of China. It has also affected the international coal market and it increased total world's coal trade volume as 943 billion tones in 2009 (Wang et al, 2013).

3.2. OIL

China has 18,1 billion barrels of proven oil reserves that accounts for 1,1% of world's total oil reserves and it has 11,9 years of reserves to production ratio of oil reserves in 2013. In the decades, the amount of oil reserves of China has not changed excessively, since it has only 15, 2 billion barrels in 2000 that increased 3 billion barrels in thirteen years, which can be explained with lack of the discovery of unproven oil reserves (BP, 2014). China has mature oil fields to extract oil reserves but at the same time, there have been newly founded offshore and onshore oil fields in the western interior area. Bohai Bay and Southeast China Sea have the newly founded offshore oil reserves. The largest onshore oil fields are located in the northeast and north central parts of the country. The oldest oil field as Daqing fields, the second largest oil field as Shengli oil field, and Changqing field in the northwest as the third largest oil field, and Liaohe and Jilin fields in the Northeast, are China's four largest heavy oil fields in the north central basin (EIA, 2014).

Figure 5: Chinese Oil Reserves



Source: U.S. Energy Information Administration

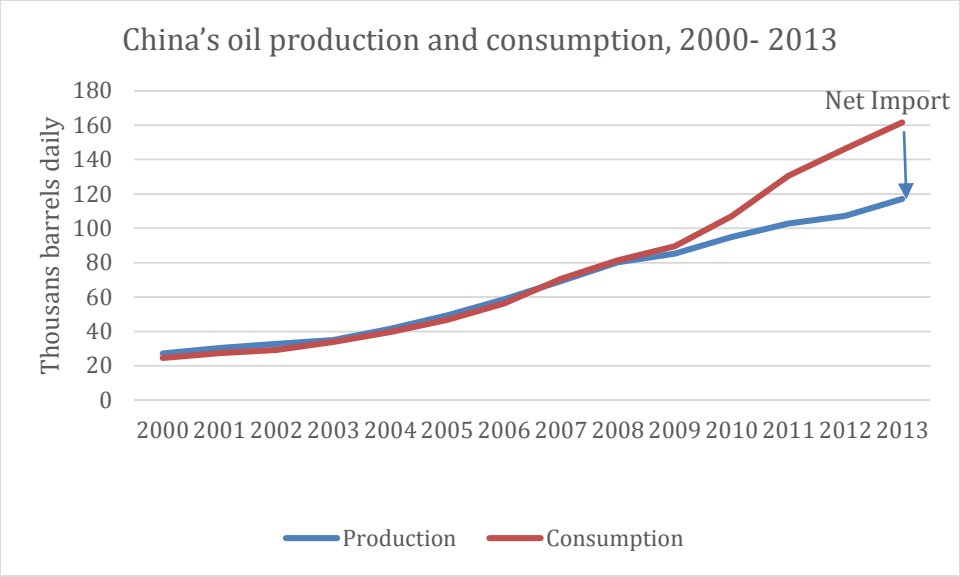
In Figure 5, there are the onshore and offshore oil fields of China, those are located in the north east, northwest and north central parts of the country and onshore, offshore oil reserves also located in the southeast, northeast and eastern part of China.

China is the fourth largest oil producer with a rate of 4,1 million barrels per day by 2013, and 5% of total oil production of the world. At the beginning of 2000s, oil production of China was 3,25 million barrels per day whilst it was under the 500 thousand barrel per day at the beginning of 1970s. After, the OPEC crisis in 1973, the amount of production was increased over 1,3 million barrels per day (BP, 2014). For the crude oil production, there

has been national oil companies that are possessing significant role in the Chinese oil sector. China National Petroleum Corporation (CNPC), the China Petroleum and Chemical Corporation (Sinopec), PetroChina, The China National Offshore Oil Corporation (CNOOC) are the most important oil refinery and producer companies of China. Daqing and the Liaohe & Jilin fields belong to CNPC with an oil production amount of 800, 000 bbl/d of Daqing and 200,000 billion barrel per day (bbl/d) of Liaohe and Jilin field as China's largest heavy oil field. Changqing field, China's third-largest oil field, also belongs to CNPC that has more than 13% annual growth rate between 2008 and 2012 with production of 451,000 bbl/d in 2013. Shengli oil field that is near to the Bohai Bay belongs to Sinopec with a production about 550,000 bbl/d of crude oil. (Feng et al, 2013). However, CNOOC is the company that is responsible for offshore oil exploration and production especially in the South China Sea, East China Sea and Bohai Bay which is the oldest offshore crude oil reserve area with a production of 406,000 bbl/d of COOC. CNPC also has exploration area in that basin but has a relatively small amount of production of 200,000 bbl/d in 2012 (EIA, 2014).

Moreover, China is the second largest oil consumer in the world following United States with 10,7 million barrels per day in 2013. Until the beginning of the 2000s, the oil consumption of China has been regularly increasing from 4,8 million barrels per day to more than two times (BP, 2014). Similar to the reason of increasing coal consumption, economic growth is also the reason of the increasing demand in oil resources in China that is caused by evenly increasing GDP growth of the country (IEA, 2011).

Figure 6: China's oil production and consumption, 2000 2013

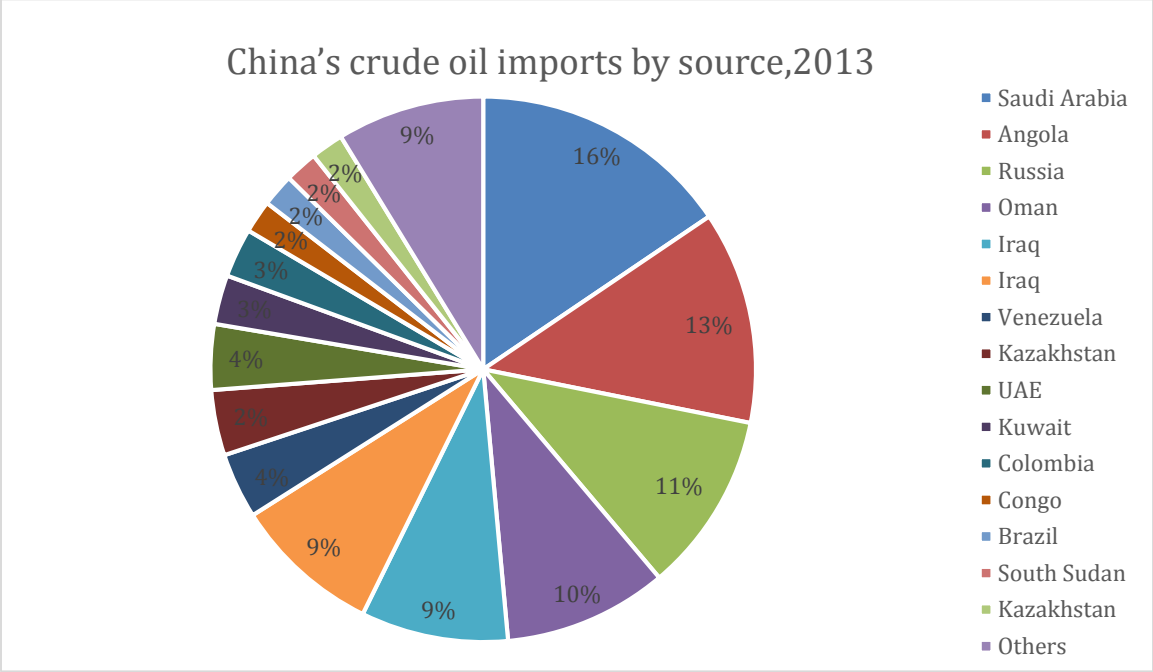


Source: British Petroleum, 2013

In the Figure 6, the consumption and production levels of China are shown from the beginning of the 2000s to 2013. After 2003, the oil consumption has exceeded the oil production level, which has led to import oil from other countries. China increases its import level year by year due to slow growth of oil production in the country and it became a net oil importer in 2003. China imported nearly 6.2 million bbl/d of crude oil on average in 2014, rising 9% from 6.6 million bbl/d in 2013. China's crude oil imports is expected to increase to high level of 7.4 million bbl/d in 2015. In 2014, the Middle East supplied China with 3.2 million bbl/d (52%). Other regions that export oil to China include Africa with 1.4 million bbl/d (22%), the Americas with 667,000 bbl/d (11%), Russia and the former Soviet Union with 778,000 bbl/d (13%), the Asia-Pacific region with 127,000 bbl/d (2%), and 27,300 bbl/d (<1%) from other countries. Saudi Arabia and Angola remain China's two

largest sources of oil imports, and together they account for 29% of China's total crude oil imports. (Feng et al, 2013).

Figure 7: China's crude oil imports by source



Source: US Energy Information Administration, 2013

Chinese international oil suppliers is divided into five regions including; Middle East, North Africa, West and Southern Africa, Eurasia, South America and Asia Pacific. In the past ten years, sixteen countries from these regions have been exporting oil via tanker and pipeline connections. Cniese oil import is 5,4 million bbl/d via vessel, pipeline import of China is from Russia and the former Soviet Union with 778,000 bbl/d. The Middle East countries have the largest share as oil import partners of China in the history with 52% of total oil import with 3,2 million bbl/d, Saudi Arabia has the largest share with 16% among all importer countries. They are followed by Angola with 13%, Russia with 11%, Iran with 9%, Oman with 10%, Iraq with 9%, Kuwait with 3,9%, UAE with 4%, In the North Africa,

Sudan with 2% and Libya with 1,9% are the other significant oil exporter countries of China at the beginning of 2012. African countries as Angola and Congo have also important roles as oil exporter with 14,2% and 2,2%, respectively that makes Angola the second largest oil exporter country of China after Saudi Arabia in 2013 (Sun et al., 2014). In Eurasia region, Russia and Kazakhstan has also share in oil export to China; Russia with 7,7% and Kazakhstan with 4,1%. Moreover, share of Russia has increased because of oil trade deals between Russia and China, estimated to be close to 1 million bbl/d of crude oil by 2020. Venezuela and Brazil are South American countries which export crude oil to China by 4,4% and of 2,8% respectively, via tanker to the port of China (Wu, 2014).

Figure 8: Chinese oil pipeline

Source: US Energy Information Administration, 2015

In Figure 8 shows the current and planned oil pipelines of China that is coming from Kazakhstan, Russia and Myanmar, tanker terminal point of China that provides flow of

imported oil tankers, and the refinery area of China. Pipeline connection with Kazakhstan and Russia are the alternative routes to diversify oil import suppliers of China via vessel. The international oil pipeline was established and become operational in 2006 to transport Kazakh and Russian oil with a 240,000-bbl/d capacity through 1,384 miles of length (Fenget al, 2013). This pipeline was developed as Sino-Kazakh Pipeline by the investment of the CNPC and Kazakhstan's KazMunaiGaz (KMG) and connected with its domestic pipeline line by 11,795 miles. Eastern Siberia-Pacific Ocean Pipeline (ESPO) has become operational in 2011 that has a 600,000-bbl/d capacity in the first stage from Russia (Taishet) to Skovorodino, then to China with 300,000 bbl/d, which was built by CNPC with the agreement of Russia and China. The capacity of ESPO is expected to be increased to 1.6 million bbl/d by 2018. China has also signed an agreement with Myanmar even it is not significant oil producer to construct an oil pipeline from Myanmar to Yunnan/Anning refinery of China. It would bypass the Strait of Malacca as an alternative route for Middle East oil and would become operational in 2014 with a 440,000 bbl/d capacity (EIA, 2014).

3.3. NATURAL GAS

During the last two decades of the 20th century, natural gas resource was developed and became an important fossil fuel in Chinese energy mix. New discoveries of natural gas reserves in territory of China were started because of the evaluation of the new gas industry (Higashi, 2009). Moreover, intensive economic growth in the last decade in China is another reason of increasing natural gas exploration and extraction activities in both onshore and offshore gas basins (Zoller, 2013). During the 1990s, natural gas reserves were about 1,4 trillion cubic meters, but new discoveries of natural gas reserves have started

after 2007, and it was increased to 2,3 trillion cubic meters in 2007. Proved recoverable natural gas reserves of China is 3,3 trillion cubic meters equivalent to 1,8% of total natural gas reserves of the world in 2013 and reserves to production ratio is 28 years for Chinese natural gas reserves (BP, 2014).

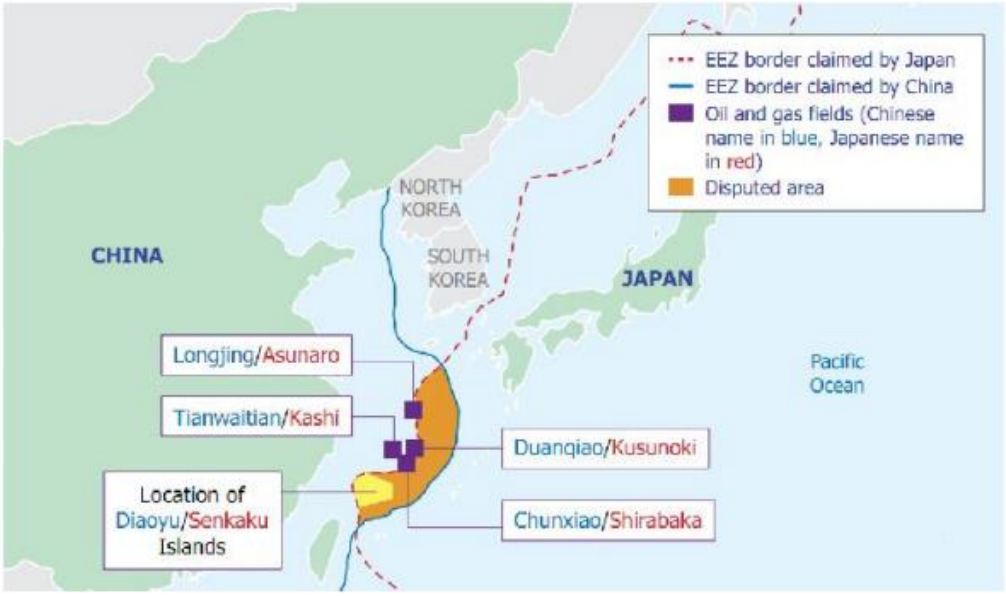
Figure 9: Gas Reserves in China

Source: China National Petroleum Corporation

Figure 9 shows onshore and offshore natural gas reserves basins of China in terms of their size and amount of natural gas resources. The major gas fields are located in western and north central part of the country, and most of the gas reserves has link with oil reserves of China except the Sichuan gas field. Geological feature of the natural gas reserve basin of China makes difficult to extract and produce natural gas, also the share of sand and tight gas is increased in the new discoveries, but the quality of gas is decreased (Kang, 2014). There are four major natural gas production basins in China including the Ordos Basin, the Sichuan Basin, the Tarim Basin and the South China Sea that produce the 90% of total natural gas of the country (Higashi, 2009). Sichuan Basin is the largest natural gas

production area, where it is estimated that Yuanba and Puguand fields will produce 13,1 bcm of natural gas in 2016 under the control of Sinopec and Chevron also constructed two natural gas plant with 7,5 bcm production capacity. Tarim basin is the second largest basin with 19 bcm of natural gas production for 18% of total gas production of China. Ordos basin including the Sulige and Changbei fields have 0,03 tcm of gas production although they have the largest reserve capacity by 1,05 tcm, but the region has geological challenges and is holding the tight gas. The last one are the offshore natural gas fields that are located in the East China Sea, South China Sea and Bohai Bay controlled by CNOOC and Husky Energy which is a Canadian Oil Company. South China Sea is the largest offshore natural gas basin with 0,18 tcm of proven gas reserves while the Yacheng 13-1 field is the largest offshore natural gas field that is the primary source of Hong Kong (Higashi, 2009). According to EIA (2014), East China Sea has between 0,03 bcm and 0,06 tcm of proved offshore natural gas reserves by being the second largest offshore gas field, but the region has significant potential of 7,5 tcm unproven gas reserves in the Okinawa trough. However, there are Exclusive Economic Zone (EEZ) dispute between China, Japan and Taiwan over East China Sea control and Seabed Oil & Gas resources (Hsiung, 2005). United Nations (2013) states that in Article 56 and 57 '*The exclusive economic zone shall not extend beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured'*. An the coastal state has '*sovereign rights for the purpose of exploring and exploiting, conserving and managing the natural resources, whether living or non-living, of the waters superjacent to the seabed and of the seabed and its subsoil, and with regard to other activities for the economic exploitation and exploration of the zone, such as the production of energy from the water, currents and winds'*.

Figure 10: Japanese and Chinese EEZs, and the location of oil and gas fields in the East China Sea



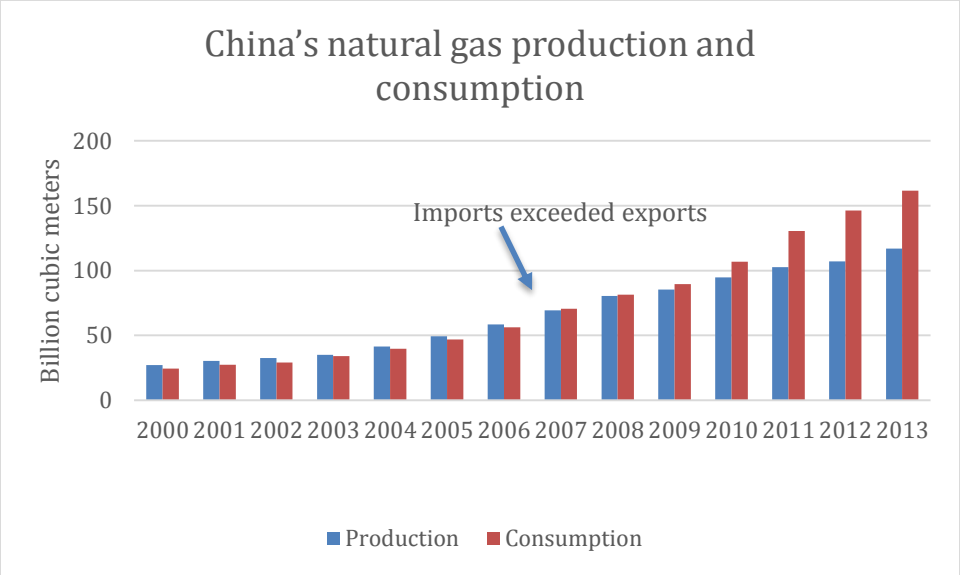
Source: US Energy Information Administration

In Figure 10, Japan claims the application of the equidistance (median-line) approach. The median-line approach means the Japanese, demand to attraction the line western of the Senkaku and Diaoyu Islands. China and Taiwan don't accept the line over Senkaku and Diaoyu Islands that is claimed by Japan, because Taiwan also claims control over these islands. There is the restriction of the maritime border somewhere between the median line and China's 200 nautical miles EEZ line. China claims that on the application of the principle of natural prolongation of the continental shelf which allows claims up to 350 nautical miles from the coast, China claims an area extending from its coast up to the Okinawa Trough with 2000m in depth (Bendini, 2014).

Chinese natural gas production has been rising year by year after 1980s by 8% of average growth rate of natural gas production from 1980 to 2013, but in 2008 the annual growth

rate of natural gas production had peak point by 18% because of the increasing consumption of natural gas in China (Kang, 2014). The production amount of China was 14,3 bcm in the beginning of the 1980s, but recently, Chinese natural gas production extremely increased to 117,1 bcm accounting for 9,5% of world's total production as the sixth largest natural gas producer in the world. (BP, 2014). According to China Energy Fund Committees (2013), Chinese volume of conventional natural gas production will be 138,5 bcm in 2015 and 200 bcm in 2020, including tight gas; therefore, the conventional gas production will peak in the next two decades.

Figure 11: China's natural gas production and consumption 2000-2013

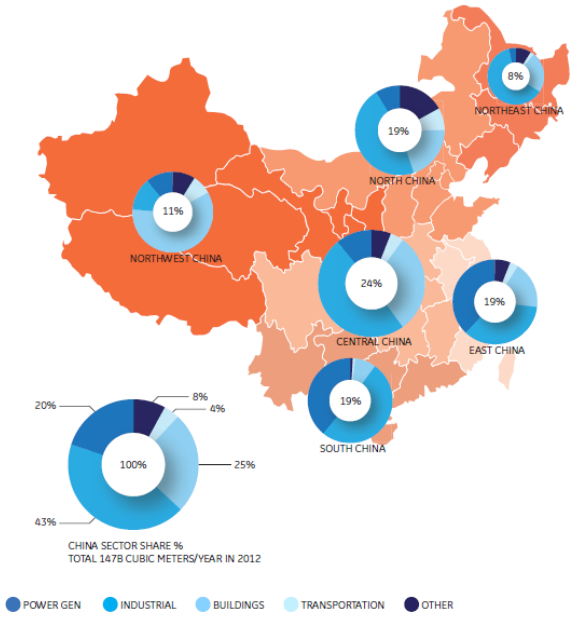


Source: British Petroleum, 2013

In Figure 10, natural gas production and consumption of China is shown from the year 2000 to 2013. As shown in the chart, the consumption level surpassed the production level in 2007, and import of the natural gas has begun after the year of 2007.

Natural gas consumption effectively increased from 24,5 bcm to 56,1 bcm between the years of 2000 and 2006, the quantity of production was higher than consumption before 2006 (Kang, 2014). After 2007, the natural gas consumption increased to 70 bcm, and the annual growth rate of natural gas consumption has grown by 11,8% in one year (Higashi, 2009). Recently, the volume of natural gas consumption highly increased to 161,6 bcm in 2013 with a share of 10,8% of world's total natural gas consumption making China the fourth largest natural gas consumer country (BP,2014).

Figure 12: China's Regional Gas Demand



Source: General Electric

In Figure 11, the consumption of natural gas by sector was shown as classified in terms of the regions of China. The highest consuming regions of China are located in the proximity of the production fields. Central China has the highest consumption rate with 24% of total consumption of China that is close to production province of Sichuan. The three regions of China have the same amount of consumption by 19% as the second largest consumer

regions including east, north and northeast China. In the coastal area of eastern China in the province of Shanghai, Beijing and Tianjing, natural gas consumption has been increasing until 2000 from 2% to 19% of regional gas demand. The north China is near to Ordos's natural gas basin that led to high natural gas consumption in the region of Changqing. Northwest China is the third largest consumer region by 11% of consumption with the Tarim production field in the province of Xinjiang. The least consuming region of China is northeast region with the share of 8% of total Chinese gas consumption (Farina and Wang, 2013).

3.4 RENEWABLES

Renewable energy resources including *hydropower, wind, solar, geothermal and biomass*, started to be important energy resources in last decades because of the global warming issues. As much as they are friendly for environment with near-zero carbon emission, they are also alternative for fossil fuels to reduce their dependency (Lil et al., 2015). The share of world's total renewable resources is 19% of total energy consumption and 22,1% of total global electricity production at the end of 2013 (REN21, 2014). In recent years, China became an important global actor in renewable energy because of the increasing energy consumption and economic growth. Also, China is abundant in renewable energy resources, Chinese renewable energy capacity and potential made China a global leader (Remap 2030, 2014). However, renewable energy in China is still at initial stage for power generation. Hydropower has the largest share for electricity production of China by 22,5% among renewable energy resources. Wind power follows hydropower as the second resource by 6,1% and the last renewable energy resource is solar power that has share for power generation of China by 0,8% (Shen and Luo, 2014).

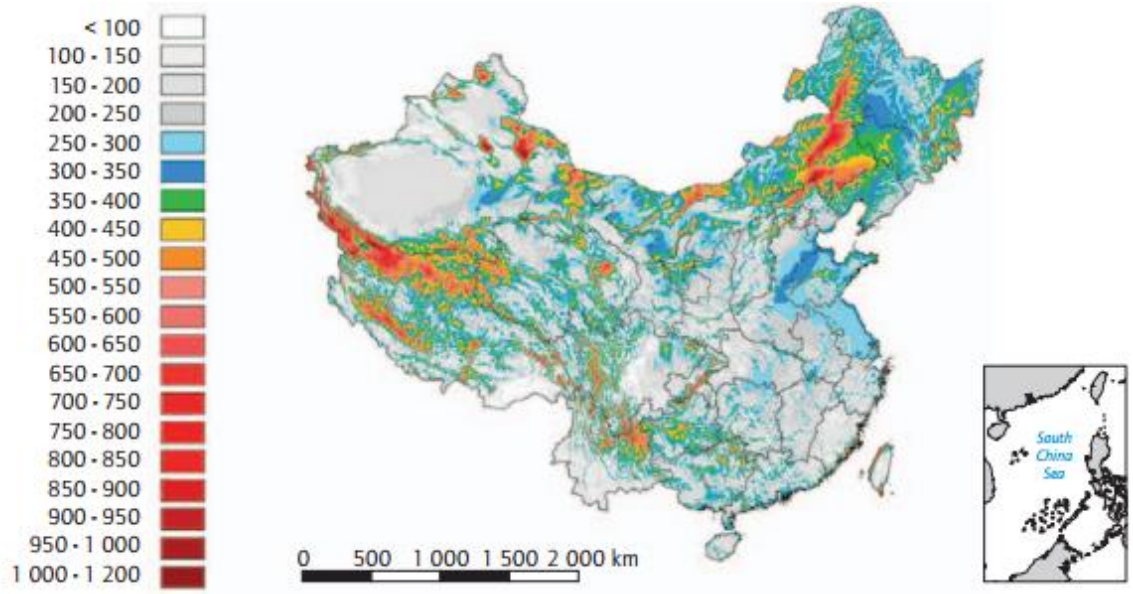
Hydropower is one of the important resources among renewable energy resources, in terms of both electricity production and installed capacity power in China. It is an abundant resource in China that makes it leading hydropower capacity country by 26% of global capacity. End of the 2013, China has 260 GW hydropower capacity and 905 TWh generation as the largest hydroelectricity producer country in the world (Ren21, 2014). Until 2004, Canada was the leading hydroelectricity consumer country, but China firstly exceeded United States by 277TWh in 2001 after surpassed Canada by 353 TWh consumption in 2004 (BP,2014).

China has large capacities of rivers in its basin area of 100 km^2, and Southwest of China is the most fertilized region for hydropower resources which includes Sichuan, Yunnan, Tibet and Guizhou provinces. Middle and South China are the second rich regions for hydropower generation in the country, and then North China is the last region for hydropower with regard to fruitfulness (Huang and Yan, 2009). The first hydropower plant was established in 1912 with 500 kW installed capacity in Yunnan province. Most of the hydropower resources are located in the regions that have not coal reserves like Liaoning, Jilin, Zhejiang, Fujian, Jiangxi, Hubei, Hunan, Guangdong, Guangxi, Chongqing, Sichuan, Yunnan, Guizhou, Shanxi, Gansu and Qinghai. There are thirteen largest hydropower basins and rivers including Jinshajing River, Yalongjiang River, Daduhe River, Wujiang River, the Yangtze River Up Reaches, Qingjiang River, Nanpanjiang River and Hongshuihe River, Lancangjiang River, the Yellow River Up Reaches, the Yellow River Main, West Hunan, Fujian and Zhejiang and Jiangxi, the Northeast and Nujiang River, which occupy 42% of total hydro capacity of the country (Cheng et al, 2012). Three

Gorgeous Project is the biggest hydropower station project in the world that started to be established in 1994 to develop Yangtze River by 18,2GW installed capacity and 84,6 TWh power generation. According to 12th Five year plan, installed capacity of hydropower of China will increase to 290 GW at the end of 2015 by 68,2% of renewable electricity production of China. In 2020, hydropower capacity will reach 420 GW by targeting construction of more than 50 large scale dams to meet that amount of electricity production (REMAP2030, 2014).

Wind is the *second* renewable energy resource with regard to power generation by 6,1% of Chinese total electricity production. Chinese total wind installed capacity is 91,4 GW by 140 billion Kwh power generation that makes China leading wind capacity country (Ren21, 2014).

Figure 13: Distribution of land-based wind resource potential

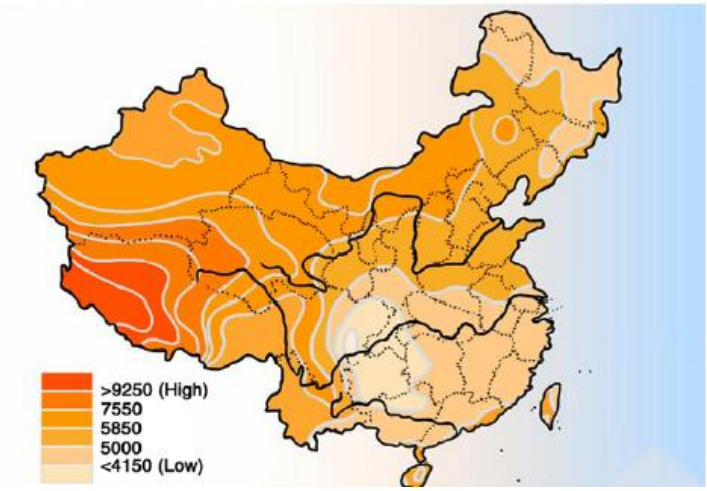


Source: Energy Research Institute

The map shows wind resource potential of China, red colored regions are the most suitable areas to construct wind turbines to get efficiency from wind resource. For onshore wind energy, Inner Mongolia, Xinjiang Hami, Gansu, Jiguan, Hebel and Jilin are the most convenient areas with highest wind potential, and offshore fields are located in near the Jiangsu provinces (IEA, 2011). Chinese wind sector rapidly grew because of government policies. Wind Power Concession Project is one of the initiatives of government to develop wind energy sector in China. Reducing the in-grid wind power tariff and incentives for companies to develop renewable energy resource were realized by government to develop wind energy. China has huge wind energy potential but coal is still the cheapest energy resource, and because of that government incentives and subsidization of private companies has important role to secure wind energy in Chinese energy mix (GENI, 2006). China has large area of shallow sea that makes offshore wind potential much more promising than onshore due to high and more stable wind speed. By 2013, offshore installed capacity of China is 428 MW as the fifth country of the world, but it is estimated to increase to 5 GW in 2015 and 30 GW by 2030 (GWEC, 2014).

Solar power is the *third* renewable energy resource that generate electricity by 0,8% of total electricity production. Solar Photovoltaic capacity of China is approximately 20 GW as the second largest country after Germany in the world. Western provinces are more concentrated than other regions that it is shown in the below map in dark orange (Ren21, 2014).

Figure 14: Distribution of solar power resource in China



Source: CMA Wind and Solar Energy Resources Assessment Center

However, China is the leading country of the world in terms of solar thermal heating and cooling by 46,2 GW of solar thermal capacity equivalent to 64% of global capacity. At the beginning of 1980s, solar thermal capacity has increased to become leading solar thermal market. Furthermore, China is the world's largest photovoltaic panel manufacturer and it exports 95 % of its production, equivalent to 74% of world production output (Yu and Quo, 2013). Solar energy is also abundant in Chinese territory, two-thirds of land area of China acquires 2200 hours of sunshine a year. Qinghai, Xinjiang, Tibet, Inner Mongolia, Sichuan and Gansu Provinces have the most efficient provinces for solar PV capacities in the country (Shen and Luo, 2015).

China has also *geothermal* reserves, but not much abundant with 27 MW installed capacity by 0,2 % of world total capacity (BP, 2014). Since 1999, geothermal energy was used in China for heating and recreation, not in electricity production. China mostly has low temperature geothermal reserves, but few regions also have high temperature geothermal reserves including southern Tibet, western Yunnan and western Sichuan that is called

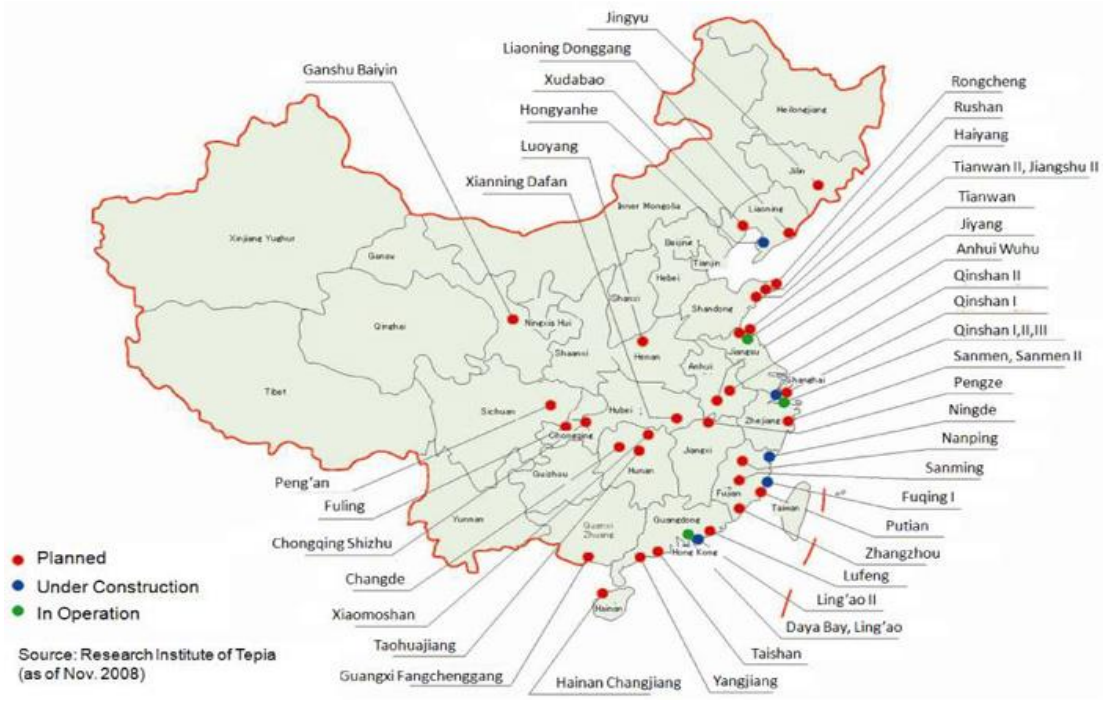
Himalayan Geothermal Belt. Yangbajing geothermal power plant is the largest capacity by 25,2 MW out of 27 GW that has been in operation since 1977 in Tibet. China targets to increase its capacity to 50 MW by 2015. The rest of the power plants are located in Tibet, Hunan and Guangdon provinces with much smaller capacities (REmap2030, 2014).

Biomass is also a large energy source in China because of the rural area production, 80% of biomass energy is procured from crop residue of rural population. In the western rural area, 4 billion tons of crop residues are burnt in the stoves to obtain biomass energy (GENI, 2009). Total installed capacity of biomass power of China is 14,4 MW by 31,9 million toe amount of energy, and power generation capacity is 45,5 billion kWh in 2013. It is estimated that total installed capacity will increase to 34,5 MW and 74 million toe of biomass energy at the end of 2020. The amount of energy will be obtained 50% from rural residue, 20% of manure and 18% of rubbish. Chinese government has the policy to develop renewable energy in rural region of the country, because the importance of biomass power is increasing in recent days to decrease coal consumption in those regions. In China, about 900 million tons of forestry waste and three branches are available in a year, which can produce 300 million tons of biomass energy, equivalent to 200 million tons coal production. Thus, using wastes to produce biomass energy decrease consumption of coal energy in rural area. For the future years, biomass energy will continue to be supported by Chinese government program (Shen and Luo, 2015).

3.5 NUCLEAR ENERGY

Nuclear energy usage has started to increase in China like renewable energy resources, 22 nuclear power reactors are in operation, and also 26 power stations are under construction. With the new power stations, Chinese nuclear capacity will reach at least 58 GWe by 2020. Recently, nuclear energy is also situated in electric production of China with 4,9 trillion kWh by increasing year by year. As it mentioned in coal part of Chapter 3, coal has the highest share by 3785 TWh in the production of electricity, but nuclear power has also share of 2,1% in total electricity production, equivalent to 1145 GWe installed capacity in 2013, which is estimated to increase 1600 GWe in 2020, and 2000 GWe in 2025 (World Nuclear Association, 2014).

Figure 15: Nuclear Energy Power Plants



Source: Research Institute of Tepia, 2008

Nuclear power plants play important role in developing countries such as China and coastal area of the country. As it shown in the map, nuclear power plants are located in coastal area, in the southern and eastern parts of China. Electricity demand of Hong Kong is met by nuclear power plant with 23% in 2014, but it is expected to be 50% of nuclear power in production of electricity. Qinshan I, II, III are in operation in the eastern part of China with the Canadian nuclear power plant technology. Daya Bay and Ling Ao plants are also second power plants that are in operation in 2006 by French-designed pressurized water reactors in south China's Guangdong province (Kadak, 2007). Nuclear energy is environment-friendly because it does not produce carbon emission or other harmful gases rather than fossil fuels. It is an advantage for China to decrease CO2 emission by 20%. Nevertheless, if the nuclear power plant accident is realized, it causes fatal effects over human beings. However, the State Nuclear Power Technology Corp (SNPTC) is importing nuclear power plant technology from foreign countries. After Fukushima accident, reliability of nuclear power is questioned, because the technology is reappraised in order to increase the safety of nuclear power plant. Chinese government evaluated the safest technology to construct power plant in mainland China. In the White Paper on Energy Policy, the safety inspections in the aftermath of Fukushima, reaffirmation of the new nuclear power technologies, and promotion of the application of advanced technology is included as China's strategy for nuclear energy (Nakano, 2013).

In conclusion, the chapter analyzes energy resources of China including Coal, Oil, Natural Gas, Renewables and Nuclear Energy on the basis of reserves, consumption, production, import and export of resources among countries. The next chapter will explain the driving forces such as internal and external aspects and effects under the local and global energy

patterns of increasing natural gas demand in China. Therefore, it is clarified why share of natural gas should be increased and how would Chinese government diversify its energy resources and how Chinese energy mix is changed in consideration of energy policy.

CHAPTER 4

DRIVING FORCES AND EFFECTS OF INCREASING NATURAL GAS DEMAND IN TERMS OF ENERGY POLICY OF CHINA

In the beginning of the 2000s, China was the natural gas exporter country with the amount of 3,14 bcm, but trade position of China has changed after 2007 from exporter country to importer country with 1.4 bcm of net gas import from other countries in 2007 (China Energy Fund Committee, 2013). According to BP (2014), the total import of China is 51,9 bcm via pipeline (27,4 bcm) and LNG (24,5 bcm). Therefore, the import dependency rate of China increased to 31,5% in 2013, in other words Chinese domestic gas market became more and more dependent to foreign gas suppliers. For pipeline imports, Turkmenistan is the leading pipeline exporter country of China with the amount of 24,4 bcm, Kazakhstan is the other country which supplies natural gas to China via pipeline with the amount of 0,1 bcm, and lastly the rest volume of 2,9 bcm import belongs to other former Soviet Union countries (BP, 2014). For LNG imports, Qatar is the leading LNG partner of China by 9,2 bcm import, then Australia follows Qatar with the amount of 4,8 bcm import as the second largest country, Malaysia and Indonesia are the other important exporter countries accounting for 3,6 bcm and 3,3 bcm, respectively. In addition to these countries, the other LNG exporter countries are Yemen (1,5 bcm), Egypt (0,6 bcm), Equator and Nigeria

(0,5bcm), Algeria (0,1bcm), Angola (0,1bcm), and Trinidad & Tobago (0,1 bcm) (Tang, 2014).

Figure 16: Natural Gas Pipeline and LNG terminals of China

Source: International Energy Agency, 2012

China has one domestic pipeline that is called West to East Pipeline, constructed in 2002 to transport western Chinese gas to east and south part of China with 11,7 bcm annual capacity. In 2011, second part of the West to East was constructed as extension of the Central Asian Gas Pipeline in China that has 11,7 bcm capacity to transport Central Asian gas to southern part of China. The third part of West to East pipeline is started to be constructed by CNPC in parallel with second part that will become operational in 2015 from Horgos Port to Shaoguan (EIA, 2014). The first international gas pipeline is Central Asian Gas Pipeline that comes from Gedaim on the border of Turkmenistan and Uzbekistan and running also from Kazakhstan to Xinjiang region in western part of China with the 31,1 bcm annual capacity. The China - Myanmar gas Pipeline is the second pipeline

connection, which was started to be constructed in 2010, assumed by CNPC, and became in operational in 2013 with 230 million cubic meters capacity. The pipeline starts from the Kyaukpyu region of Myanmar to China's Yunnan and Guangxi provinces in the southwestern region (Tang, 2014). China started to import LNG in 2006. There are twenty different LNG import terminals in China. At the end of 2013, LNG import capacity is 0,045 tcm through nine major terminals. China is the third largest LNG importer country after Japan and South Korea (Zoller, 2013). Dapeng LNG terminal is the first regasification terminal that began receiving LNG in 2006 with 26,5 Mmcm capacity. The second LNG import terminal is Fujian, its construction was started in 2004 and commissioned in 2007 controlled by CNOOC by 10,35 Mmcm capacity. Moreover, the third largest LNG terminal was started to be constructed in 2007 and become operational 2009 under the name of Shanghai LNG terminal with 11,8 Mmcm capacity (Lin et al., 2010).

4.1. Driving Forces of China in Consideration of the Increasing Natural Gas Share in Chinese Energy Mix

In the history, coal is the primary energy resource in Chinese energy mix because of the rich coal reserves that makes China primary coal producer and consumer country in the world (Yang, 2009). As mentioned in Chapter 3, although China has 114,5 billion tons of coal reserves as the third largest country after USA and Russia, it started to import coal after 2009 because production of coal cannot meet coal consumption of the country. Oil is the second primary resource, but oil is being imported by 5, 6 million barrel per day, which makes China the second largest oil consumer and importer country in the world in 2014. Share of natural gas in Chinese energy mix is the least among fossil fuel resources, but it

will increase according to 12th Five Years Plan because of the challenges in oil and coal (Lewis, 2011). It is accepted that Chinese energy policy is changed in consideration of Five Years Plans of China with the increasing of the natural gas share by 16% at the end of 2015 (Cao and Bluth, 2013).

Until the beginning of the 1990s, demand on coal is highly increased because of the economic growth of China in last three decades. Developing economy and industrial sector cause increase in the production of coal in the country, further surplus of coal production was started to be exported in 2003. However, extremely increasing coal consumption resulted in import of coal by 125 metric tons in 2009 because of the transportation bottleneck of Chinese coal resource, environmental and safety proliferation and quality of domestic coal. In 2011, China surpassed Japan as the largest coal importer of the world, and the import of coal is reached to 290 metric tons, increased by 60% per year (Wang et al, 2013). One of the reasons of increasing import of coal is transportation problems. There is a long distance between coal producer in North China and end consumer. East railway infrastructure of China and damaged roads during transportation of coal from mines to coal processing facilities is bottleneck for producing coal. According to Chinese government, increasing import of coal can be encouraged to decrease the damage of transportation roads. The second reason is the environmental problems during production and transportation process. Import coal from overseas protects local environment. The last one is the quality of coal, which has low sulfur quality. The amount of high quality of coal is low, because the import of high quality coal is more profitable (Tu, 2013). However, coal import resulted in to increase dependency to coal that has highest share in Chinese energy mix by 68% in 2013. Because of that, increasing share of coal import seems as a threat for

Chinese energy security. Thus, Chinese government's plan is to decrease to below 65% of coal share in 2017, with the increase of natural gas share among fossil fuels and increase of non- fossil fuels resource share by 15 % by 2020 to diversify coal resource (EIA, 2014).

Coal use produces the highest carbon dioxide emission in comparison to natural gas and oil. The highest share of coal in energy mix makes China the world's largest carbon dioxide emitter country. The huge consumption of coal in industry and use of solid coal on heating and cooking in rural part of China causes health and environmental problems (Cao and Bluth, 2013). As mentioned in the introduction part of study, China is the largest CO2 emitter country in the world with 9,52 billion tons carbon dioxide by 27,1% of world total emission. China is a middle-income country and has a growing economy, which is the reason of increased energy consumption; thereby the reason of increasing CO2 emission. Therefore, greenhouse gas emissions cause climate change that directly affects human and global security. Because of that, decreasing CO2 emission amount is not only the environmental problem of China, but also a global problem. However, Chinese government states that the amount of CO2 emission will be decreased by 40-45% to mitigate the effects of climate change and environmental problems by 2020 under the Kyoto Protocol (Yang, 2009).The government targets to decrease share of coal and increase natural gas share in energy mix as it has the least spread CO2 emission rate among fossil fuels (Lewis, 2011). Instead of coal, renewables can be alternative resources that are environment-friendly but costly in economic terms. Also, natural gas is another alternative, as being both more environment-friendly than coal and cheaper than renewable energy (Ji, 2014).

Increasing amount of coal consumption in China by 70% calls inevitably for taking precautions against power of coal share due to the diversification of resources policy.

Increasing dependency of coal is the threat for Chinese energy security. Share of coal dependency is important because of huge consumption of coal that also is imported like fuels. It means that it highly depends on coal exporter countries; Indonesia and Australia (Leung, 2011). China is the second largest electricity producer because of its developing economy, improvement of industrial sector and high population. Also, it is the largest energy consumer in the world, and it will reach to 4,2-4,5 billion tons by 2020. Therefore, China is the key actor in energy market because of being huge consumer for fossil fuels exporter countries (China Energy Focus, 2013).

In China, there has already been constructed natural gas pipeline, which can reach to three countries: Turkmenistan, Kazakhstan and Myanmar. Also, there are twenty different LNG import terminals in the coastal are of China. The already constructed pipeline and LNG terminals are the opportunities in terms of economy and time for the government when it diversifies of coal with natural gas. The international gas pipeline is Central Asian Gas Pipeline with 11,7 tcm annual capacity from Turkmenistan to China, also running from Turkmenistan, Uzbekistan and Kazakhstan to transport their natural gas. The other pipeline is the China- Myanmar gas Pipeline by 230 million cubic meters capacity that became in operation in 2013. China is the third largest LNG importer with the increasing amount year by year by 20,9 bcm in 2013 (EIA, 2014). China can sign agreements to import natural gas with the high volume both via pipelines or LNG because it has already constructed large capacity of pipelines and LNG terminals in China. Therefore, China makes agreement with post- Soviet countries to transport their 27,4 bcm natural gas to China; also the amount of LNG import share is increasing by 24,5 bcm in 2013 with eleven LNG exporter countries (Yang et al., 2014).

Furthermore, China is the net oil importer by 246 thousand barrels per day until 1993. Middle East was the leading oil exporter country of China until diversification period of oil with five main regions including North Africa, West and Southern Africa, Eurasia, South America and Asia Pacific. Strait of Hormuz and Malacca Strait are the choke points through sea transportation of Middle Eastern oil that are under the control of Iran and Malaysia, respectively (Vivoda, 2009). Besides, the Middle East has abundant oil resources, but also the wars and crises has never ended in that region, which creates unreliable supply. Chinese government had also oil diplomacy over Middle East, which means diversification of suppliers of oil to provide its energy security (Cheng, 2008). Iraq War in 2003 and Assad regime disputes in Syria became bottleneck to diversify Middle East oil in the last decades. In Iraq War, China started to diversify oil with different suppliers, as a dominant attempt because of the existence of American hegemony in the region, in order to get a reliable access of oil supplies. Arab Spring is also the other dispute, which could not enable Middle Eastern oil suppliers a safe way. Sanctions over Iran imposed by United States because of the nuclear program of Iran are also obstacles to take Iranian oil and gas. Assad regime disputes against its own population in Syria are the last crisis that creates unsafe oil suppliers. The last reason changing heaviness of oil supplier is terrorism, piracy and shipping accident in the ocean, and because of that, China decides to shift some of oil way away from the Strait of Malacca. Thus, oil would not be the best alternative resource to decrease coal share because of the unreliability of huge oil exporters (Cao and Bluth, 2013).

On the other hand, during last two decades, China and Russia has ups and downs in their relations, but in 2013 both parties signed an agreement with giving the highest priority to

China against its competitor to transport Russian oil to China. Also, Sino- Russian natural gas cooperation was realized unlike huge priority of oil cooperation. Gazprom started to export Altai gas to China but it has not been approved by Chinese authorities, it is not a 'must have' option for China, it is just a little step. Russia also applies its own tactic with signing agreement with China against European Union. While it exports Russian crude oil and gas to Asian market, Russia shows that it is not dependent only to the EU. Also, China has opportunity for its diversification of resources and routes policy (Palk, 2014).

4.2. Effects of Increasing Demand of Natural Gas on the Chinese Energy Pattern

China has become the world's fourth largest natural gas consumer in the last decades as a result of changing its energy strategy by increasing the share of consumption of natural gas in Chinese energy mix. Economic growth in China increases the consumption of the energy, therefore increasing natural gas consumption become inevitable. By increasing natural gas demand in China, import of natural gas started to increase after 2009 via pipeline and LNG that affects balance in Chinese energy mix and Chinese energy policy (Tang, 2014). China is one of the leading actors in the world's energy market, thus changing of its energy policy has important impacts. The significant changes about its energy strategy affect both Chinese energy pattern and the global energy pattern (China Energy Focus, 2013).

According to BP (2014), share of coal consumption has the largest percentage by 67,4%, then oil by 17.7%, hydroelectric by 7,2%, natural gas by 5%, renewables by 1% and nuclear by 0,8%. In the previous year, the share of coal and natural gas was 69% and 4%, respectively. The numbers show that there has been changes in the share of fuels in Chinese energy mix which are decrease of the coal share and increase of the natural gas share. Also,

it is expected to increase the demand on natural gas to 8% in 2025. It means that Chinese gas market will be two times larger in 2025 which makes China a significant natural gas market for suppliers (Farina and Wang, 2013). The target of Chinese government is to decrease coal consumption because of the environmental problems and increasing amount of coal import. As a result of this, its strategy is the diversification of resources by rising portion of natural gas and diversification of source by changing energy partners and diversification of routes via both pipelines and LNG. In fact, all these effects are related with each other, increase of natural gas consumption causes decrease in coal demand that provides diversification strategy of Chinese government (Lewis, 2013).

By increasing natural gas import, energy routes of China are also changed with natural gas supplier countries. In Chapter 3, it is mentioned that most of the oil suppliers are located in Middle East region such as Saudi Arabia which is the largest oil supplier of China and overseas countries. Because of that, most of the oil import is transported via vessels over Indian and Pacific Ocean to reach China. Therefore, coal is also transported by vessels through Strait of Malacca. Natural gas is imported with two ways including pipelines and LNG. There have been two main pipelines. Central Asian Gas Pipeline from Turkmenistan, Kazakhstan and Uzbekistan to China is the new trade route for China to carry natural gas. This pipeline is also an opportunity to open energy trade of China to the west (Tang, 2014). According to EIA (2014), capacity of CAGP is 31,1 bcm per year, and China imports natural gas by 39,6 bcm a year from Turkmenistan and Uzbekistan in 2013. It is expected to increase to 65 bcm per year in 2020 with the agreement between Turkmenistan and China. Therefore, China faced with the West to import energy as a new route alternative. The other pipeline is called the China-Myanmar gas pipeline as a second new route to carry

Myanmar gas with the amount of 10 bcm for 2013, but it is also expected to increase to 24 bcm by 2019 (Zoller, 2013). Therefore, import volume of natural gas via pipeline has a high share in post-Soviet countries. It is estimated that the total imports from three Central Asian countries will meet one-third of the import desired by 2030 when the construction of pipelines finishes. Also, natural gas of Myanmar that is transported from Bay of Bengal will cover 6% of Chinese natural gas import in 2030 (Odgaard and Delman, 2014). Moreover, LNG imports in China started in 2006 because of the increasing natural gas consumption. Import of natural gas also increased from 1 billion $m^3$to 20 billion m^3 in six years, and it reached to 24,5 billion $m^3$by 2013 (BP, 2014). China is the third largest LNG importer country after Japan and South Korea in the world. The main LNG exporter countries of China are Qatar with 7,5 bcm LNG import volume, Australia with 4,5 bcm LNG import volume, Malaysia with 3 bcm and Indonesia with 2,5 bcm LNG import per year. The other seven exporter countries are Yemen, Russia, Egypt, Nigeria, Trinidad & Tobago, Oman, and Algeria (Tang, 2014). There are twenty different LNG import terminals in China. Dapeng LNG terminal, Fujian LNG terminal, and Shanghai LNG terminal are the three largest terminals of China that has the largest capacity among twenty terminals. Dapeng has the 26,5 Mmcm capacity that become in operation since 2006, Fujian terminal started to operate in 2007 by 10,35 MMcm capacity, lastly Shanghai LNG terminal - the third largest LNG terminal - has 11,8 Mmcm capacity until 2009 (Lin et al., 2010).

Another new policy of Chinese government that is situated in 12th Five Year Plan is about natural gas price policy, because expensive natural gas price affects demand of natural gas both in industries and households. While determining natural gas pricing in China,

wellhead price, city-gate price and end consumer price are the important indicatives that cause price variation among cities. In different cities, end consumer price shows differences because of discrepancy of the well-head stage and the city-gate prices. For example, the average of wellhead price is RMB 1.022 per cubic meter in Changqing, whereas Xinjiang has RMB 1.015 per cubic meter wellhead price. Moreover, city gate prices of in Guangxi and Guangdong provinces were set at RMB 2.74 per cubic meter and RMB 2.57 per cubic meter respectively. Due to the variation of prices in different cities, residential and industrial gas prices shows difference between each other and cities. Industrial gas price in Beijing by 2013 was recorded at RMB 3.23 per cubic meter, while residential gas prices were verified at RMB 2.28 per cubic meter. In other main gas consuming cities' like Zhejiang, Guangdong, and Shanghai, industrial gas prices are set at RMB 4.84, 4.85, and 4.59 per cubic meter respectively (China Energy Focus, 2103). The wholesale natural gas price was controlled by government that cause losses for Chinese gas importer companies due to lower domestic rates. The Chinese government reformed natural gas pricing and changed from a government-regulated model to a market-oriented model in 2013. However, the reform initially contained non-residential gas consumer which means that incentive policy of government protects now only residential consumers. The country's wholesale gas markets were divided in two tiers, in terms of incremental volumes and base volume of their consumption, while pricing their natural gas usage. The government takes a step for gas importing markets of China while increasing gas pricing by RMB 400 per thousand cubic meters for non-residential consumers. Gas pricing reform is not only sufficient to impact natural gas demand, but also it is required to make reforms for electricity price reforms, controlled by government (Ling, 2014). Piped gas and LNG

pricing has also differences, as the average of LNG price and piped gas price is by US$ 13.8 per MMBtu and US$ 9.78 per MMBtu in 2013, respectively. Moreover, LNG prices shows difference in terms of exporter countries since Australian and Indonesian LNG are the cheapest cargoes with an average price of US$ 3 to 4 per MMBtu. Qatar is the most expensive exporter by US$ 17.32 per MMBtu, although it is largest LNG supplier of China. Pricing of pipeline gas of China has slight differences such as US$ 8.63 per MMBtu for Uzbekistan gas, US$ 9.94 per MMBtu for Turkmenistan gas, and US$ 11.68 per MMBtu for Myanmar gas, while comparing LNG pricing range. Although delivered cost of piped is cheaper than LNG, transportation tariffs, West to East, should be taken into account, including actual cost between LNG and pipeline gas imports (King and Spalding, 2014). Pricing of imported natural gas has crucial effects over the increase of its demand, particularly in spite of cheaper prices of coal. For instance, prices of base and incremental gas volumes of Guangdong province is RMB 0.97 per KwH and RMB 1.17 per KwH respectively, while the conforming price of coal is simply RMB 0.3 per KwH. Even if environmental cost of coal generation is still higher, generation of gas power plant is more expensive. Nevertheless, higher pricing of natural gas will assist future LNG and pipeline imports in the long term. However, Xizhou Zhou, director of IHS Cambridge Energy Research Associates, stated that 'IHS estimates that the reduction in coal prices has saved utilities more than RMB 500 billion ($83 billion) between 2011 and 2013. Meanwhile the total cost of the premium paid to add new gas-fired power is estimated at only RMB 10 billion ($1.6 billion) over the same period' (Dong, 2015).

Consequently, diversification of resource and sources provides energy security of China while increasing share of natural gas consumption. Thus, dependency portion of coal

exporter countries is decreasing or is shared with natural gas exporters. Changes over transportation routes via pipeline provide new alternative routes to import natural gas, and increase of LNG imports promotes the changes in main energy supplier countries of China. Thereby, Chinese government have been arranged for new gas pricing policy in terms of increased natural gas demand and import providing energy security of China.

4.3. Effects of Rising Chinese Natural Gas Consumption on Global Energy Patterns

China is the world's most populous country and it is also the largest energy consumer and producer country due to growing economy. Because of that, China has crucial influence on the global energy markets. Any little change in the Chinese energy pattern directly affects global energy market, because slight difference in consumption or production means large amount compared with low population countries (EIA, 2014). It is mentioned that China is the leading CO_2 emitter country with 9,52 billion tons carbon dioxide out of 35 billion tones in 2014 (BP, 2014). Coal is also highly responsible for greenhouse gases and increasing environmental problems as a result of CO_2 emission. However, increasing natural gas consumption promotes decreasing coal consumption and therefore, CO_2 emission starts to decrease in China and whole world (Yang, 2009). Natural gas has environmental advantages in comparison to other fossil fuels, and natural gas combustion produces no sulfur dioxide and particulate emission unlike coal and oil. If China continues to decrease coal consumption and increase natural gas share in its energy mix, 1,3 billion tons of CO_2 emission reduction can be realized until 2020 (Shuo and Myllyvirta, 2014). Energy partners of China are also changed after increasing natural gas need, import of natural gas is also increasing based on consumption. As it is mentioned in the previous

section, coal partners of China are Australia and Indonesia, oil partners are mostly Middle Eastern countries. By importing natural gas via pipeline and LNG, Chinese energy partners become post-Soviet countries Kazakhstan, Turkmenistan and Uzbekistan, also LNG exporter countries become Qatar, Australia, Indonesia and Malaysia. Turkmenistan is the largest foreign natural gas supplier of China, expanded its production for the Asian giant under the bilateral agreement between two parties. In 2009, Turkmenistan and China made the first agreement to carry Turkmen gas to China via Turkmenistan-Uzbekistan-Kazakhstan-China pipeline. Over half of Chinese natural gas import is accounted by Turkmenistan, it was 21,3 bcm export volume in 2012, but it is increasing year by year to 30 bcm annually in 2014. It is expected to increase to 65 bcm export to China in 2020 (Sadykov, 2014). Kazakhstan and China have also pipeline connection, same pipeline with Turkmenistan, to carry Kazakh gas to China. Kazakh and Chinese collaboration started in 2010 by signing joint venture agreement to construct pipeline from western pipeline connecting with CAGP line. It will be third phase of the pipeline by 24,6 bcm capacity in a year that began operations in 2014 (EIA, 2014). Also Uzbekistan has a deal to join the agreement between three Central Asian countries to deliver 9,8 bcm Uzbek gas in a year through another transmission line connecting with CAGP. It has started to be constructed as a fourth line of CAGP in 2013; it is expected to be in operation in 2016 to add Uzbek gas in to CAGP line capacity (Tang, 2014). After increasing natural gas consumption, LNG import is increasing with the increase in the share of LNG export countries. Qatar has largest share of LNG import by 34% among exporter countries. Qatar and China has the long-term contract to ship Qatari gas to China. However, Chinese LNG strategy is to diversify its LNG imports from other regions like Middle East and African countries.

Furthermore, Australia is the best option to diversify these regions, thus Chinese companies make agreement with Australia by 4,8 bcm import in 2013(EIA, 2014). Indonesia is the third LNG import partner of China by 16% of share among countries. Partnership between China and Indonesia goes back a long way; the first energy contact between two parties were signed in 2002 to carry per 3.4 billion cubic meters LNG per year to China. The amount of LNG is increased due to increasing demand in China, therefore the energy relationship between two parties is getting stronger and the parties reviewed their long-term 25 years agreement in 2012 (W, 2013). As it was mentioned before, Russia and China have important role over global energy sector as the world's two key energy actors. Russia is the neighbor country of China with abundant energy resources, and it is the second natural gas producer country after United States. The energy partnership between the second largest gas producer and the largest energy consumer is really important for global and regional gas market. Russia has the super-giant gas fields in its territory that is mostly located in eastern Siberia which has border with China. However, the point is that the natural gas production in the region is expected to increase up to 132-152 bcm in 2030 (Zoller, 2013). The gas trade relationship between Russia and China goes back to 1990s, the first agreement between CNPC and Russian Energy Ministry was signed in 1994 to construct gas pipeline between two countries in order to carry Eastern Siberian gas to China with an independent company named Sidanco. In 2006, Gazprom started to be responsible from exporting Russian natural gas to the world. It is only the negotiation foundation, but it does not own Siberian gas. The first export was realized in 2011 with the volume of 68 bcm per year between China and Russia. After Gazprom bought the license of Siberian gas fields, some matters came to the agenda between two countries, including routes and prices,

in 2011. Two parties had different opinion about routes and price of natural gas. While China defended eastern route to take gas from Russia in order to solve shortage problem of the province of Jilin, Liaoning and Heilongjiang, Russia prioritized Altai route to deflect Siberian gas' surplus in that region. Despite the fact that Russia suggested gas price of $350 per thousand cubic meters, China offered US $235 per thousand cubic meters for Russian gas (Weser and Murray, 2014). Although there have been some disagreements between China and Russia, Gazprom and CNPC has signed an agreement to carry 38 bcm Eastern Siberian gas to China via new pipeline that will be in operation by 2018. The routes of pipeline were settled under the agreement but the price is still not defined by force of Gazprom on the eastern routes with lower contact volumes. Moreover, Sino-Russian gas trade cannot reach its full potential because of these disagreements about price and routes (Skalamera, 2014).

In conclusion, the driving forces and local and global effects of increasing natural gas consumption in China clarified in detail. The next chapter of the study will be analysis and findings chapter by answering questions as follows: What is the rationale behind increasing natural gas consumption in Chinese energy mix? What would be impact of increasing natural gas consumption on Chinese foreign policy making, especially towards the supplier countries? How could China secure its additional natural gas supply? Via piped gas or LNG or both? What are the possible implications of new Chinese policy, considering the environment and the globe?

CHAPTER 5

ANALYSIS AND FINDINGS

The '*Analysis and Findings'* chapter will be demonstrating the response of the determined research questions that are indicated in the introduction part of the study, in the consideration of energy security perspective. It is stated in the previous chapters that China is the world's most populous country which makes it the leading energy consumer and producer country of the world. In the history, the primary energy resource of China is coal by 67, 4% accounted for 1,925 Mtoe, but it is planned to decrease coal consumption year by year to 65% by 2017, 63% by 2020 and 55% by 2040 in consideration of new energy policy of Chinese government. In Chinese energy mix, furthermore, natural gas is the best alternative among fossil fuels to diversify coal. Natural gas has 5% of total energy consumption of China by 2013, but it is estimated to increase to 8% by the end of 2015 and 10% by 2020 (EIA, 2014).

The *first research question* of the study is about *rationale behind increasing natural gas consumption in Chinese energy mix*. Increasing share of natural gas in Chinese energy mix is new energy policy of China. There have been multiple driving forces, divided into two aspects as an internal and external. Internal reasons are also allocated into four sections in

itself including; *(1) extremely increasing coal consumption and production, (2) environmental problems, (3) threat for energy security of China, and (4) already constructed natural gas import infrastructure*. External reasons of changing energy policy of China are *(1) the crisis in the Middle East* and *(2) Sino-Russian energy cooperation*. The *first reason* of increasing natural gas consumption is *extremely increasing coal consumption and production*. Coal is the primary energy resources and has 67% of total energy consumption of China that led to be highly depended on coal. After starting to import of coal in 2009, it also makes to be depended both coal and coal suppliers, because of that it needs to diversify coal with natural gas as the best alternative resource (China Energy Focus, 2013). The *second reason* of rising share of natural gas demand is *environmental problems* caused by to high coal consumption. It was mentioned before that increased coal consumption causes important environmental problems including air pollution and CO_2 emission. High coal consumption of China makes it the world's largest carbon dioxide emitter country with 9,52 billion tons carbon dioxide by 27,1% of world total emission. Natural gas is the best alternative that has half CO_2 emission than carbon. *Another reason* of the changing balance in energy mix of China is *threat for energy security*. Increasing share of coal much more than half of total energy consumption makes diversification of resources certainly. Dependency of coal is increasing respectively with increasing coal consumption that is the threat for Chinese energy security. Diversification of resources and routes is essential point for China to acquire energy security or eliminating threat on energy security. Furthermore, it is also provided to make diversification of source (natural gas suppliers) and routes (pipeline or LNG) thanks to different suppliers. Thus,

new energy policy of China that is increasing share of natural gas also strengthened energy security of China (Cao and Bluth, 2013).

The *last internal reason* is *already constructed natural gas import infrastructure* which led to accept natural gas as a best alternative against coal. There has already been constructed international natural gas pipeline of China that are Central Asian Gas Pipeline with 11,7 tcm annual capacity to transport Turkmen and Kazakh natural gas, and China- Myanmar gas Pipeline with by 230 million cubic meters capacity. Also, there are twenty different already constructed LNG import terminals in the coastal area of China that are the opportunities for the government when it makes diversification of coal with natural gas. Already constructed natural gas infrastructure that becomes profitable in terms of both economics and time, provides to make long term agreement with natural gas supplier countries including; Russia, Kazakhstan, Turkmenistan and Myanmar via pipeline, and Qatar, Australia, Malaysia and Indonesia, Yemen, Egypt, Equator, Nigeria, Algeria, Angola, and Trinidad & Tobago via LNG (Tang, 2014). As *external reasons*, increasing *crisis in Middle East* is the first reason to diversify coal with natural gas. China makes trades with Middle Eastern countries with oil through first Hormuz Straits which is controlled by Iran and Malacca Straits, but it needs to decrease share of coal not to by oil due to the crises because it makes Middle Eastern countries unreliable supply. The *last external reason* of changing share of resource in energy mix is *Sino-Russian Energy cooperation*. In 2013, China and Russia signed an agreement to transport Russian oil to China as an alternative source of Middle Eastern countries. Moreover, the results of new natural gas policy of China made Sino- Russian natural gas cooperation a unique huge priority of oil cooperation. Gazprom and China signed agreement to export Altai gas to

China as an opportunity for both sides. Russia can use as a leverage against European Union because China is the huge energy market. Also, it has opportunity for diversification of resource, source and routes policy of China to provide its energy security (Palk, 2014).

The *second research question* is about *impact of increasing natural gas consumption on Chinese foreign policy making, especially towards the supplier countries*. The changes of Chinese energy policy affect both Chinese energy pattern and the global energy pattern. Three main impacts have occurred on Chinese energy patterns including; *(1) changing share of fuels in its energy mix (diversification), (2) changing energy transportation routes, (3) increasing LNG import, (4) piped gas & LNG pricing*. The *first impact is changing share of fuels in its energy mix*. Share of coal consumption has the largest percentage by 67,4%, then oil by 17.7%, hydroelectric by 7,2%, natural gas by 5%, renewables by 1% and nuclear by 0,8%. However, the share of coal consumption is decreasing in last years, and it is expected also to decrease the increasing share of natural gas from 5% by 2013 to 8% by 2025. *Another effect* of increasing natural gas demand on Chinese energy structure is *changing energy transportation routes*. Increasing natural gas consumption led to increase natural gas import via pipeline and LNG. New trader countries and new imported routes of China are also appeared with increasing natural gas consumption. Trading routes of China were mostly African and Middle Eastern countries, which bring their fuels via vessels through sea routes over Pacific and Indian Ocean. After increasing natural gas trade, sea routes are one of the ways to carry LNG to China, but pipeline with Russia, Turkmenistan, Kazakhstan, Uzbekistan and Myanmar is the good alternative for China to carry natural gas (Tang, 2014).*The third effect* on Chinese energy patterns by increasing natural gas demand is *increasing LNG imports of China*. Increasing natural gas

consumption affects increasing LNG trade of China and makes China the third largest LNG importer country after Japan and South Korea in the world. After 2006, LNG trade of China is increased over twenty times rising to 24,5 billion m3 by 2013 (BP, 2014).The main LNG exporter countries of China are Qatar with 7,5 bcm LNG import volume, Australia with 4,5 bcm LNG import volume, Malaysia 3 bcm and Indonesia 2,5 bcm LNG import per year. The other seven exporter countries are Yemen, Russia, Egypt, Nigeria, Trinidad & Tobago, Oman, and Algeria (Tang, 2014). *The last effec*t is *piped gas & LNG pricing* to growth natural gas demand and import. Chinese government has the control as an incentive over natural gas price that has negative impacts over wholesale natural gas import companies as Sinopec, CNPC and Petro-China. Petro-China lost RMB 49 billion (US$ 7.9 billion) last year while importing gas with lower prices. Because of that, government gas price reform is taken into account in order to liberalize gas pricing system while passing to a market-oriented model for non-residential gas users. The pricing of imported gas is an average of US$ 13.8 per MMBtu for LNG and US$ 9.78 per MMBtu for piped gas. Although, piped gas is still cheaper than LNG, transportation cost is a determined factor, assessing actual cost for end consumers. Prices of natural gas have importance on the increase of natural gas demand rather than coal even if prices of coal are still cheaper. However, in the long term, higher prices of natural gas will assist to obligate gas import in the future (King and Spalding, 2014).There has been *three main global effect*s of increasing natural gas demand in China including; *(1) reduction in CO2 emission, (2) changing energy partners, and (3) Sino-Russia natural gas import*. The *first effect* is the *decreasing amount of CO2 emission* in China and also in the world. China has carbon emission reduction policy as the leading carbon emitter country that has directly effect of the world's carbon

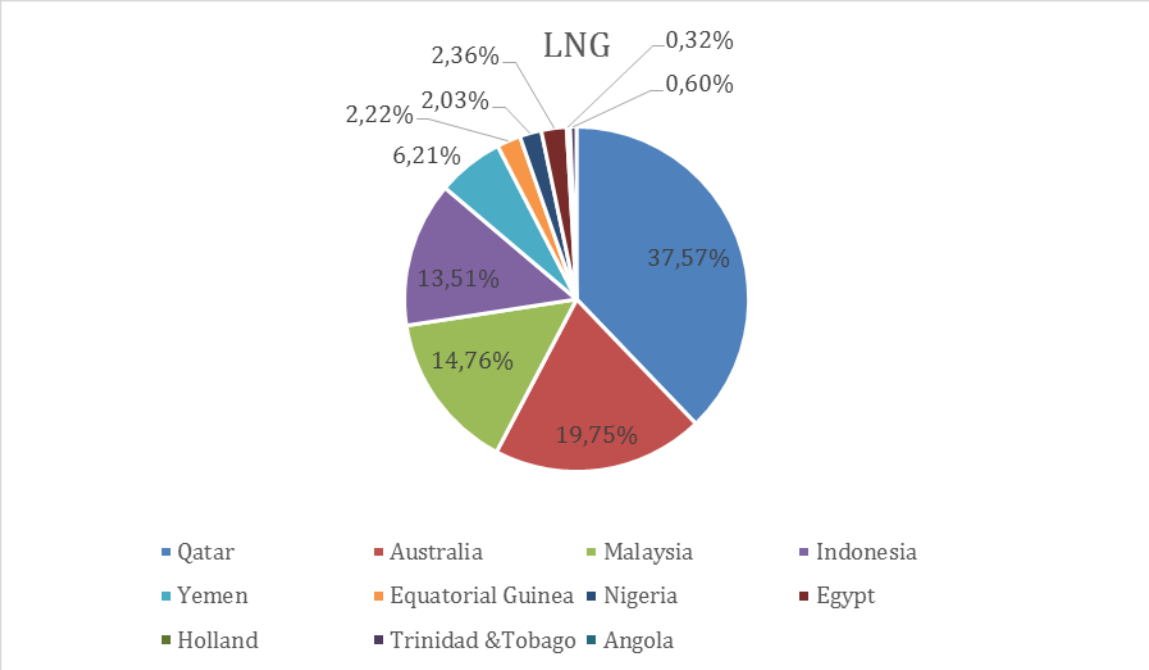
emission ratio. The initiative reason of that is extremely high coal consumption which is highly responsible for greenhouse gases and increasing environmental problems. Therefore, increasing share of natural gas decreased coal and less carbon gases will be emitted to the environment. Also, it is expected to realize 1,3 billion tons of CO2 emission reduction until 2020 that decrease air pollution and environmental problems both for China and the world (Shuo and Myllyvirta, 2014). *Another effect* of rising demand on natural gas is *changing energy partners*. It is mentioned in the previous part of conclusion which is about diversification of resources that also led to diversify energy partners (suppliers).By importing natural gas via pipeline and LNG, Chinese energy partners become Russia and post-Soviet countries including Kazakhstan, Turkmenistan and Uzbekistan and also LNG exporter countries; Qatar, Australia, Indonesia and Malaysia. The largest foreign natural gas supplier of China is Turkmenistan, and its production is expanded after the bilateral agreement with the Asian giant, carrying Turkmen gas to China via Turkmenistan-Uzbekistan-Kazakhstan-China pipeline in 2009. Turkmenistan supplies over half of Chinese natural gas import accounted for 30 bcm annually in 2014. The other imported natural gas trader partner of China is Kazakhstan that is carried its natural gas through same pipeline connection with Turkmenistan with constructed pipeline as a third phase of CAGP by 24,6 bcm capacity. Also, Uzbekistan is involved with the agreement to deliver 9, 8 bcm Uzbek gas a year through another transmission line connecting with CAGP (Tang, 2014). Qatar is another important trader country for China to carry Qatar gas via LNG that has the largest share of LNG import by 34% among exporter countries. Australia is the best option to diversify Middle Eastern countries and it is the second LNG trader country by 4,8 billion cubic meters. Indonesia is the third LNG import partner of China by 16% of share among

countries by 3.4 billion cubic meters LNG in 2013. Their trade relationship was started in 2002, and is getting stronger by reviewing their long-term 25 years agreement in 2012 (EIA, 2014).The *last effect* on global energy patterns is *Sino-Russo gas agreement* that is important for both parties and also for the globe because the key actors of energy market are involved in the agreement. Changing policy of China with increasing natural gas consumption affects relations of Russia and China, positively. The energy partnership between largest gas producer and largest energy consumer country has really important for global and regional gas market. Two giant actors of energy market decided to make natural gas agreement to carry Russian gas to China via pipeline. Although agreement between China and Russia dates back to the beginning of 1990s, the agreement could not to be totally realized because of the variance about routes of carrying natural gas. Even if some disagreements still continue between two parties, Gazprom and CNPC has signed an agreement to carry 38 bcm Eastern Siberian gas to China via new pipeline route which is settled under the agreement but the price is still not defined, with the effect of Gazprom on the eastern routes with lower contact volumes (Skalamera, 2014).

The *third research question* is about *to secure its additional natural gas supply via piped gas or LNG or both*. China has the fast growing economy by increasing population that impacts increasing energy consumption, correspondingly. Currently, natural gas consumption has been continually increasing according to the country's 12th Five-Year Plan. According to BP Energy Outlook 2035, China will become the largest energy importer country of the world by 2035 besides the world's largest energy producer and consumer country. Increasing natural gas import has really affected the leading energy importer country and such imports will be provided via LNG or pipelines. By 2013, natural

gas consumption is increased at the rate of 12%, and import dependency is increasing to 30 % approximately. It is expected to rise by 10% at the end of 2014 that means an increase of total imports to nearby 52 bcm. China becomes important actor among natural gas importer countries through connections with Central Asia and Myanmar and in the future, with Russia by signing agreement between CNPC and Gazprom about Russia's Siberian gas fields. China becomes LNG importer in 2006, and piped gas importer in 2010 which have approximately equal to import share as 47% and 53% respectively of aggregate import.

Figure 17: LNG exporter countries of China

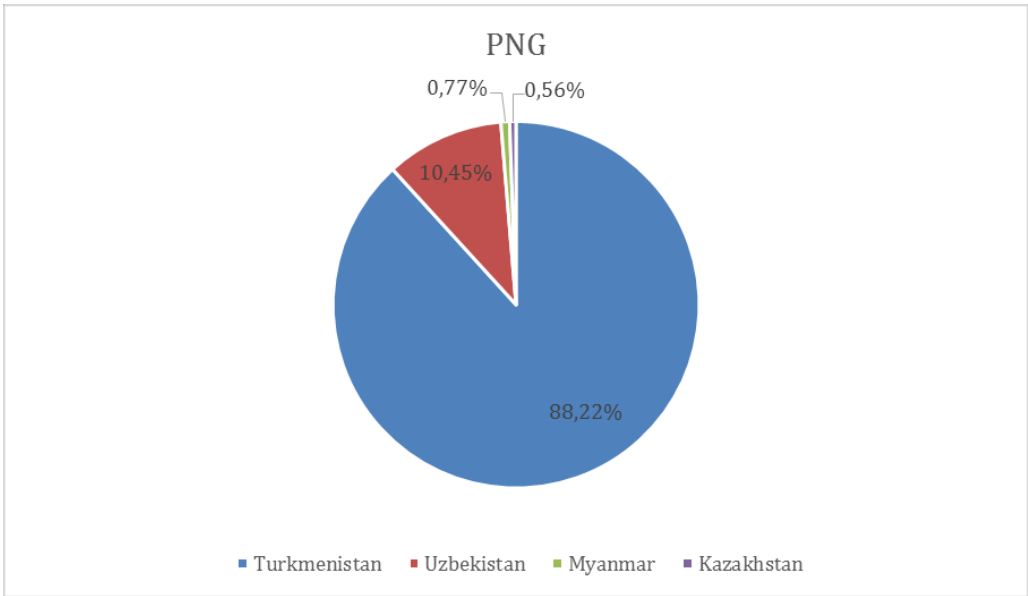


Source: China's maritime customs data

As it is shown in Figure 16, LNG trading partners are diversified by thirteen different countries since Qatar, Australia, Malaysia and Indonesia has highest share by 85% of aggregate LNG imports. Also, China has ten major already constructed LNG receiving

terminals including; Guangdong Dapeng, Fujian, Shanghai, Zhejiang, Zhuhai, Tianjin FSRU, Jiangsu Rudong, Dalian, Tangshan and Hainan that enables to acquire 35 million tons per year. Furthermore, the Chinese desire to increase its LNG terminals receiving and regasification capacity with under construction terminals by another 20 BCM by 2016 to import more LNG, but already constructed terminals have an opportunity to make an agreement, initially. Thus, China can provide secured LNG by diversifying LNG suppliers and already constructed 10 major receiving terminals (King and Spalding, 2014).

Figure 18: Piped Natural Gas (PNG) exporter countries of China



Source: China's maritime customs data

There are four main piped natural gas exporter countries of China. Turkmenistan has the largest share among piped natural gas exporter countries by 88.2% via the agreement with CNPC and Turkmen Gas for 25 BCM of gas per year. It is expected to increase to 65 BCM per year imports from Central Asian country by 2020 with such additional gas imports being supplied from the Galkynysh field. The capacity of CAGP will raise at least 55 BCM

per year by 2015 which is almost equal to LNG import. Also, it is planned to increase Uzbek gas by 10 bcm per annum in the next years with the agreement signed between CNPC and Uzbekneftegaz. Furthermore, Myanmar and China has also current agreement to carry Myanmar gas via Sino-Myanmar pipeline to reach at least 10 bcm per year. Also, there is planned gas pipeline between Russia and China by signing agreement between CNPC and Gazprom to carry 38 bcm Russia's Siberian gas to China via new pipeline that will be in operation in 2018 (Tang, 2014). Therefore, new policy of China about piped gas is also diversification of suppliers that led to a beginning of trade with different regions and routes. The capacity of the pipeline is increasing to carry more piped gas which can manage more natural gas demand. Indeed, both piped gas and LNG secure its additional natural gas supply because they creates, most importantly, the diversification of routes and suppliers, then piped gas has an opportunity with increased capacity agreement with Central Asia countries and planned gas pipeline with Russia. LNG provides freedom to import gas from any gas exporter country in the world without border with the countries.

The *fourth research question* is about *the possible implications of new Chinese policy, considering the environment and the globe*. The important reason of increasing natural gas demand instead of coal and establishing new energy policy in China is environmental problems. China is one of the favor country of the Kyoto Protocol signed by China in 1998 to reduce greenhouse gas emissions which causes air pollution and health problems. Chinese government assumed the 12th Five-Year Plan which set new targets and policies for 2011-2015 and allocates significant attention about energy and climate change (Lewis, 2011). The main aim of the governments is decreasing 16% reduction in energy consumption, increasing non-fossil energy by 11% of total energy use, reduction 17% in

carbon emissions, gas consumption rising from 108 Bcm in 2010 to 230 Bcm in 2015, gas imports rising from just 17 Bcm to 93.5 Bcm Also, increasing natural gas consumption instead of coal is the crucial factor to decrease carbon emission, because natural gas has about half of CO_2 emission than coal. Therefore, government has also targets about increasing natural gas share that are involved in the 12th Five-Year Plan.

It is also published by China Energy Fund Committee (CEFC) about driving forces of increasing natural gas consumption as environmental problems (Forbes, 2014).The world countries desire to decrease carbon emission rate of China, because China has 27% of world's total carbon emission. If China reaches the targets of carbon emission reduction, the world countries will also be affected environmentally, not only China itself. Because of that, USA is willing to help and share its experiences about managing carbon emission reduction policy of China. Moreover, Sarah Forbes, who is senior associate at the World Resources Institute, stated that '*affordable natural gas could be a benefit not only for China, but the global energy market and international climate change mitigation efforts.'* Also, she believes and suggested that *'the United States should share its experiences and challenges with shale gas to help responsibly unlock this promising resource*. *Besides conducting substantive collaboration on environmental regulations for air, water, and climate impacts, the two countries should also address barriers to small company involvement that could open doors for more business-to-business cooperation.'* (Dong, 2015).

CHAPTER 6

CONCLUSION

'Conclusion' chapter will analyze the reasons why China has decided to increase the share of natural gas in its energy mix and the possible impact of this demand for the future Chinese energy security and global gas trade. It is mentioned in *Literature Review* chapter of the study that there are multiple definition of concepts of energy security, hence this study analyzed energy security with 4A+D dimensions that are *Availability, Affordability, Accessibility, and Acceptability plus Diversification*. The reasons of why share of natural gas is increased in Chinese energy mix will be investigated from the perspective of the 4A+D dimensions. Chinese government decides to reform its total consumption share of the resource because of extremely increasing coal consumption by 68% of total energy consumption in 2013. Natural gas is regarded as the best alternative resource instead of coal that led to increase its share approximately 5% of China's energy primary sources in 2013. Furthermore, before the decision of increasing natural gas share, it should be made researches whether it is *Available* or not. Natural gas reserves of China are 3,3 trillion cubic meters by 2013 which is the huge amount for some countries as Turkey by 45,6 bcm consumption per year. However, China is the most populous county of the world by 1,36 billion people, because of that reserves to production ratio of natural gas is 28 years for China related with rapidly increasing natural gas demand. Hence increasing natural gas

consumption of China cannot be met by Chinese indigenous natural gas resources, thus import of natural gas is required to have energy security in China. Moreover, natural gas should also be *Affordable* to provide energy security. Chinese government has control over natural gas price to incentivize natural gas market while protecting consumers. However, new gas price reform is targeting to liberalize natural gas pricing system for non-residential gas users. Pricing of natural gas is an important actor over its demand, particularly due to the considerably lower prices of coal. However, in the long term, higher natural gas prices will meet future price of LNG and natural gas consumption. *Accessibility* of natural gas is easy while importing via both vessels and pipelines. China has geographically an advantage to import pipeline natural gas from its neighbor countries including Turkmenistan-Kazakhstan-Russia via Central Asian Gas Pipeline (1,1 bcm), Myanmar via Myanmar-China gas pipeline (230 million cubic meters) and LNG from Qatar (9,2bcm), Australia (4,8 bcm), Indonesia (3,3 bcm), and Malaysia (3,6 bcm).Also, natural gas should more *Acceptable* rather than coal while increasing its share in the energy mix of China. China is the world's leading CO_2 emitter country with 9,52 billion tones carbon dioxide. Because of that, one of the main goals of 12^{th} Five Years Plan of Chinese government is carbon emission reduction. Natural gas is more environment-friendly and producing less greenhouse gases. In order to achieve target of the government by 1,3 billion tons of CO2 emission reduction until 2020, natural gas is the best solution while decreasing coal consumption and production, correspondingly. Diversification of resources is the last and most important reason to increase share of natural gas. Coal has the highest share by 68% of total energy consumption which makes highly dependent on coal. While increasing natural gas demand, China firstly enables diversification of resource in its energy mix, then

different natural gas supplier countries causes to diversify of sources as Turkmenistan, Kazakhstan, Russia, Myanmar, Qatar, Australia, Indonesia and Malaysia. Also, routes of importing natural gas are different than coal that has two ways to import natural gas, via pipeline and LNG. Routes of piped gas are running from western and northern part of China that is completely different from coal import route. LNG cargoes come from sea route through Strait of Hormuz and Malacca Strait.

There are both negative and positive impacts of increasing demand of natural gas for the future Chinese energy security and global gas trade. The possible impacts over Chinese energy security are changing share of fuels in its energy mix as a positive impact, pricing of natural gas as a negative impact. Share of natural gas is increased to 5% by 2013, 8% by the end of 2015 and 10% by 2020 because of the above-mentioned reason while decreasing coal share to 68% by 2014 and expects to decrease to 63% by 2020 and 55% by 2040. Together with that, dependency on coal, which has extremely largest share, will decrease that affect positively energy security of China. Correspondingly, CO_2 emission will be decreased while decreasing coal consumption in the country. On the other hand, increasing share of natural gas has negative impact as high price of natural gas. It is accepted that natural gas price is higher than coal price and because of that; Chinese government has to apply incentive policy especially for residential consumers which cause monopoly of state owned companies in natural gas market. However, new energy policy of government from a government-regulated model to a market-oriented model about gas pricing is reformed for non-residential consumer which is the beginning for the development natural gas sector. Finally, China has important impacts over global energy market, and because of that, increasing share of natural gas in Chinese energy mix will also affect global gas trade both

positively and negatively. Importing of natural gas of China affects global gas trade and causes change of trade balance in the world. Russia, which is the largest natural gas exporter country by 225.5 bcm, targets to trade with the Asian countries as China, Japan, South and North Korea. Also, China (CNPC) and Russia (Gazprom) has agreed to carry 38 bcm Russia's Siberian gas to China via new pipeline that will be in operation in 2018. Therefore, huge natural gas market will be open for Russia and Post-Soviet countries that led to increase natural gas trade for the world. Also, natural gas consumption of the world will increase by more than 50% and accounts for one quarter of world's energy consumption by 2035 which has important impacts on the increase of Chinese energy demand and import. Nevertheless, the negative impacts on the increase of natural gas demand both in China and the world is increasing natural gas price by $3.07/MMBtu in 2015 and $3.48/MMBtu in 2016. Hence, increasing natural gas import affects natural gas prices in the world because of demand-supply chain. Finally, by considering the fact that share of natural gas increases in Chinese energy mix, it affects both natural gas trade balance of the world and Chinese energy security while changing share of fuels in its energy mix.

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