ASSESSMENT of ENERGY SECURITY of SELECTED AFRICAN COUNTRIES:
A BENCHMARK ANALYSIS

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ABSTRACT

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Energy security is a significant issue for all countries. Since World War 1 period, countries give particular importance to this concept for having secured energy system in overall. In the beginning, the energy security concept was limited with the security of supply approach by importer countries. Especially, United Kingdom, France, Germany and Italy were the main countries who tried to find solutions to keep their imports and domestic energy facilities secure. These first and common approaches of energy security underlines that the energy should be constant and uninterrupted flow with an affordable price. The contemporary energy security concept has a more extended focus to follow current developments and improvements in the energy sector. New perspectives and approaches are added to the general concept to fulfill both importer and exporter countries' demands and expectations. Energy resource availability, affordability, environmental acceptability, energy accessibility, carbon dioxide emissions, diversification, dependency and energy intensity are some of the new dimensions added to energy security concept by authorities, researchers, policymakers and companies in the sector.

The objective of this thesis is to examine and evaluate the energy security situation of African countries and provide suggestions for improvement via benchmark analysis. In addition, in the literature review the indicators, dimensions and aspects that are used to analyze energy security are listed and grouped. Each selected African country is representative of a region in the continent and has significant resources in at least one type of energy source. That is, Algeria for North

Africa and natural gas, Nigeria for West Africa and crude oil, South Africa for the South of the continent, both nuclear energy and coal, lastly Egypt is for Northeast and natural gas and crude oil sources. Nine indicators are used in order to find out analyze the current situation of their energy security. Norway, Kazakhstan and Australia are included in the benchmark analysis.

Keywords: Energy security, Algeria, Egypt, South Africa, Nigeria, 4A's, Energy security indicators, Norway, Australia, Kazakhstan

ÖZET

SEÇİLMİŞ AFRİKA ÜLKELERİNİN ENERJİ GÜVENLİĞİNİN DEĞERLENDİRİLMESİ VE KARŞILAŞTIRMALI ANALİZİ

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1.Dünya Savaşı döneminden beri bütün ülkeler bir bütün olarak enerji sistemlerini güvende tutabilmek adına 'enerji güvenliği' kavramına özel olarak önem verirler. Başlangıçta, enerji ithal eden ülkeler kavrama sadece tedarik güvenliği üzerinden odaklanan bir yaklaşım içerisindeydiler. Özellikle, Birleşik Krallık, Fransa, Almanya ve İtalya başta olmak üzere hem ithal ettikleri enerjinin hem de yerel faaliyetlerinin güvende olması için farklı çalışmalarda bulunmuşlardır. Bu birincil ve yaygın yaklaşım enerjinin sürekli ve kesintisiz bir akış içinde olmasını, bu akışında karşılanabilir bir fiyat üzerinden olmasının enerji güvenliği kavramının olmazsa olmazı olarak değerlendiriyordu. Günümüzdeki enerji güvenliği anlayışı bu yaygın anlayışın ötesinde daha geniş bir odak ile konuyu ele almaya çalışır. Bunun sebebi ise gelişen ve değişen teknoloji başta olmak üzere diğer yeniliklere ayak uydurabilmektir. Enerji güvenliği kavramı, gelişen ve yenilenen bakış açıları ile aynı anda hem ithal eden hem de ihraç eden ülkelerin beklentilerini ve taleplerini karşılayabilecek bir yaklaşıma dönüştü. Enerji kaynağı kullanılabilirliği, satın alınabilirlik, çevresel kabul edilirlik, enerji erişilebilirliği, karbondioksit emisyonları, çeşitlendirme, bağımlılık, enerji yoğunluğu kavrama gelişim sürecinde araştırmacılar, otoriterler ve firmalar tarafından eklenmiş yeni boyutlar ve göstergelerin başlıcalarıdır.

Bu çalışmanın ana amacı Afrika ülkelerindeki mevcut enerji güvenliği durumunu analiz etmek ve değerlendirmektir. Ayrıca karşılaştırmalı analiz ile var olan durumlarını geliştirmek adına öneride bulunur. Buna ek olarak, litaratür

incelemesinden elde edilen ve göstergeler ve yaklaşımlar incelenip, gruplandırıldı. Bu gruplandırılan göstergeler ülkelerin enerji güvenliği ve karşılaştırmalı analizde kullanıldı. Her bir seçilen Afrika ülkesi hem kıta içerisinde bir bölgeyi hem de sahip olduğu kaynaklar ile en az bir enerji türünün temsilcisidir. Cezayir kıtanın kuzey bölgesini ve doğal gazı, Nijerya Batı Afrika'yı ve ham petrol rezervlerini, Güney Afrika kıtanın güneyini ve hem nükleer enerjiyi hem de kömür rezervlerini temsil ederken, Mısır kuzeydoğu bölgesini ve doğal gaz ile ham petrol rezervlerini temsil etmektedir. Karşılaştırmalı analiz için ise, Kazakistan, Norveç ve Avustralya tercih edilmiştir. Literatür taramasından elde edilen ve gruplandırılan dokuz farklı gösterge ile ülkelerin hem kendi içlerinde hem de karşılaştırmalı olarak enerji güvenliği durumları analiz edilmiştir.

Anahtar Kelimeler: Enerji Güvenliği, Cezayir, Mısır, Güney Afrika, Nijerya, 4A's, Enerji güvenliği belirteçleri, Norveç, Avustralya, Kazakistan

To My Parents

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CHAPTER 1

1. Introduction

Energy security is a multidisciplinary concept, which includes engineering, technological studies, geopolitical issues, political understandings, military and security perspectives, international relations, economical and environmental aspects. Energy security is composed of these various and numerous topics making it worldwide concern. It was created by politicians in the beginning of the 1910s, in order to accomplish diversification in oil supply. Since that day, the topic evolved and was enriched by authors, policymakers, market players and researchers. At first, the concept was related to security of supply against the possible risks and uncertainties in the system by authorities. The main aim was to fulfill countries' demand while considering economical and environmental issues. Generally, that objective was examined in three categories similar to energy trilemma index of World Energy Council (WEC);

- **Physical security,** which includes the interruptions of energy sources and failures in the energy systems
- **Price security,** which focuses on dealing with sudden economic fluctuations and protecting the economy as a whole
- **Geopolitical security,** which covers the shortages from terrorist and cyber attacks affecting both external and internal distribution lines to the country (Gunningham 2012; WEC, 2012; Rehner and McCauley, 2015)

Then, understanding of energy security concept expanded and enhanced by sectoral developments. In general, the steadily increasing demands and changes to improve quality of services were the main reasons of sectoral developments. This study examined historical progress of the energy security with demonstrating different perspectives.

In this thesis, selected African countries energy security situation analyzed with the indicators which are gained from literature review to examine the condition descriptively. In addition, in order to understand in a better way benchmark analysis applied with three countries. Kazakhstan, Norway and Australia are the example countries for benchmark analysis with selected African countries and with the results of that comparison, a guideline formed for the countries. The main contribution of thesis is to evaluate and examine African countries energy security conditions. Africa is selected as main focal point because there are so limited sources for the country and rarely studied subject in overall.

1.1 Historical Background and Overview of Energy Security

Energy takes on a vast and important role in every country's agenda: heating, transportation, reserves, extraction, investments, importing or exporting, oil, natural gas, diversification, supply, efficiency, policy, greenhouse gas emissions, demand, renewable energy, sustainability, availability, affordability and more. All of them are components of energy, either input or output. Each of the components related with energy has a potential risk for any time period. In 1913, Lord of the Admiralty Winston Churchill asserted in that "Safety and certainty in oil lie in variety and variety alone." Churchill's approach is commonly associated as a definition of the concept of energy security. "Since Churchill's day, the key to energy security has been diversification. This remains true, but a wider approach is now required that takes into account the rapid evolution of the global energy trade, supply-chain vulnerabilities, terrorism, and the integration of major new economies into the world market" (Yergin, 2006). As cited from Yergin, countries tried to secure their energy issues under the current and developing situations. As always, wars brought innovations, discoveries and perspectives, which could be used for any situation by human beings. Winston Churchill and Georges Clemenceau stressed the significance of oil supply security in order to keep their armies fueled in World War I. Germany and Japan also aimed to control the oil supply during World War II (Yergin, 1991). As an outcome from warfare situations, security of supply terminology began to gain importance. In the 1950s and 1960s, electricity and/or energy had reached many people; so as a result, the demand on energy increased worldwide – especially the rise driven by North America, Europe (by a majority western part), the Soviet Union and Northeast Asia. Simultaneously, the economic growth and motorization bolstered living conditions in these countries, which also increased demand. According to Moallemi, the reductions on emission levels have also important effect on energy security and even new job opportunities in the sector (Moallemi and

Malekpour, 2018). The boost in demand had started to challenge how to control the supply and demand relationship in order to keep it in balance.

The 1970s brought new insecurity issues into the energy area. That was caused by the two oil crises, the first of which happened in 1973, when the Organization of Arab Petroleum Countries (OAPEC) embargoed oil. Importer countries had troubled days without sufficient amounts of oil supply. Most of the OAPEC countries nationalized their oil assets consistently, by degree (Yergin, 1991). Oil insecurity dragged importer countries into economic crises with slowing down the demand and increasing the inflation rates. Countries especially in Western Europe started to implement new policies, which were mostly related to energy and supply-demand security. For the most part, domestic resources, diversification, energy efficiency and security terms started to gain much more significance than before. In the oil crises of the 1980's, the energy market was almost in recession caused by the high-energy prices and low energy demand. Global oil imports had a decline of almost 25% during the first half of the decade. Countries tried to find new alternatives to oil in order to overcome supply crises and create diversification. Natural gas and nuclear power plants gained importance to form a new energy mix. OPEC's control over oil prices turned into market-oriented prices. Some oil exporting countries steered their operations for downstream market activities in importing countries (Luciani and Salustri, 1998). Furthermore, increases in global temperature became the subject of researches and discussion, and gained importance. In the 1990s, there were enormous issues, which caused changes in energy such as the Gulf War and the collapse of the Soviet Union. The world energy market players gained optimistic perspective from the war (Yergin, 2006). During the fall of the USSR, affected economy and society came apart in the countries of the former Soviet Union. Risks associated with pipelines and transition of natural gas was noticeable, especially between Ukraine and Russia (Stern, 2006). Furthermore, accompanied by developments, demand and changes on energy; liberalization of energy industries and market became subject to agendas. In the early 2000s, energy security appeared in different types, such as high tension in areas, which were rich with energy resources. On the other hand, growth of technology led countries to develop new transportation routes and methods, for instance marine transportation. A number of nuclear power plants increased and growth in nuclear programs gained great pace. Iran's nuclear developments constituted confrontation and raised concerns on chokepoints such as Hormuz and Malacca Straits (EIA, 2012). Early natural gas crises happened in 2006 between Ukraine and Russia. This issue persisted through 2009 and culminated with the annexation of Crimea by Russia in 2014. European natural gas importers questioned those Russian crises. Except for the developments and increased use of nuclear power, several accidents also occurred in countries, such as the Fukushima catastrophe in 2011 in Japan.

1.2 Conceptualizing Energy Security

Even though there is a large emphasis on energy security concept by countries and organizations, there is still not any worldwide consensus about what energy security means. Recent literature on the subject of energy security focuses on conceptualization, both broad and specific definitions of energy security. This study examined more than hundreds of energy security studies, academic writings, reports from energy organizations and found forty-five energy security definitions, in spite of these definitions share a great amount of similarities among them. The International Energy Agency (IEA) defines energy security as *"the uninterrupted availability of energy sources at an affordable price."* Similarly, from a different source, a United Nations report from 2000 expressed the continuous availability of energy in diversified forms, including adequate amounts and at acceptable costs. As seen in these definitions by two different organizations, the perspective is still similar. As for energy security, the same condition exists for all of its sub-categories, such as energy demand security. The essence of energy demand was defined by Dannreuther as constant and secure revenue for development (Dannreuther, 2012). Daniel Yergin described energy demand security as *"stable commercial relations with their* customers, whose purchases often provide a significant part of their national revenues."* Anyone can easily find the common points among different definitions of energy security: stable energy flow and agreed-upon affordable price. Researchers criticized the countries and institutions for creating this confusing "definition situation," rather than simply accepting the established definition. Concepts of energy security are presented generically, in overly broad terms, or so detailed that they lack harmony and certainty (Sovacool and Brown, 2010). In some of the latest literature reviews, in order to enrich and develop energy security definitions, some questions and perspectives need to be added. Several studies focused the relation of energy security to the views of importing countries, exporting countries and transit countries. On the other hand, other studies sought to broaden the definition of energy security by considering, holistically, all applicable aspects: consumers, producers, values, threats, etc.

1.3 Perspectives of Importing Countries

As by nature of importer countries, security of supply is the main objective in energy security issues. Security of supply defined as which measures the sufficiency of supply in meeting energy demand in country. In order to measure sufficiency level, by setting the ratio between total consumed energy and total production (Sovacool and Ren, 2014). Unlike the common definition of energy security by energy institutions and organizations, a report from Executive Office of the President of the United States (2014) definition of energy security extensively covers energy availability, reliability, affordability and geopolitical considerations. By this point it was the first official document from a country who stated broad explanation of energy security.

Europe imports a great amount of energy and is one of the major energy importing continents in world. The EU standardized energy security measurements models, causing national initiatives and policies to align with the organization’s implementations. The EU has become progressively concerned on energy security issues since the 2000s (IEA, 2008). Even though in general European countries share concerns on over ascending energy imports in United States, the European Union has not willingly deal with maximizing energy self-sufficiency and contrariwise point out the supply source diversification (EC, 2000). The common belief on energy security concept by European countries is the certain link between energy security of supply and the policy of competition. As an example, countries such as Italy and Spain are importing gas from non-European Union countries, that trade requires specific conditions. Italy is authorized to import gas from non-EU countries when the storage capacity of country is at least equal to 10% of the annual imported volume. As well in Spanish gas transportation companies are restricted by policies to not import over 60% of natural gas from a sole country (Martin-Amouroux, 2007). The discussion towards supply security of energy from European countries has mostly been greeted as a problematic approach by energy exporter countries, especially in Russia. As in United States, there was not an explicit description for energy security in European Union’s policy papers until the 2000s. Meanwhile, the EC states that “the European Union’s long-term strategy for energy supply security must be geared to ensure, for the well-being of its citizens and the proper functioning of the economy, the uninterrupted physical availability of energy products on the market, at a price which is affordable for all consumers (private and industrial), while respecting environmental concerns and looking towards sustainable development” (EC, 2001).Also EU follows the common definition of energy security of supply from International Energy Agency and or United Nations by a majority. According to Chen, *“energy security has always been a key issue for national policymakers, yet there is no consensus on its precise interpretation.”* (Chen, Li, Wu et.al, 2018).

Energy security concept expanded with the environmental concerns from similar reports as Green Paper by EC. After a long time, the discussion was only focused on supply security or diversification on lines and source of energy. Yet no mentions made by organizations, institutions and countries on the relation between energy security and energy poverty. Japan is almost totally dependent on imported energy thus the focus on energy supply security is one of the highest level among countries who are in similar import dependency conditions. Especially with after the Fukushima nuclear accident in 2011, main energy policy highlighted the insecurity of current conditions. According to BP’s statistical review of world energy in 2017 data between 2000-2010,theaverage consumption of nuclear energy was 289,4 terawatt-hours in a year. It decreased slightly more than 50% and was 162, 9 terawatt-hours in 2011. According to a report by Japanese Ministry of Economy, Trade and Industry (METI), energy policy in Japan focused the supply variety both on source and type of energy. Additionally, some other concepts and approaches gained more importance than before; such as; energy efficiency, growth in usage of renewables, restructuring the nuclear policy and immediate recovery responses (2014). That was not first time for energy security concerns took part in reports from METI in 2010, energy security defined as “securing necessary amount of energy for areas like people’s living, economic and social activities, and national defense at an affordable price” which has similarities between common accepted definitions.

Japanese approach differs from common descriptions is with the emphasized connection of energy together people and social issues.

United States of America and China are the top two leading energy importer countries in the world, and the importance of energy security issues is increasing in those countries. Dr. Zhan Jian, a consultant for the office of the chief economist in World Bank, described China's energy security concept as developed from the basis of self-safety before 1993 to resource policy since 1993. Furthermore, his studies underlined the connection of macroeconomic and foreign policies with the energy security (Jian, 2011). China's 12th Five-Year Plan has underlined the new expansion projects in energy area with developing technological integration. The plan was mainly focused on fossil fuels, nuclear energy, renewables and the market activities in all energy trade, in order to keep balance between supply and demand. Thus, the components of the plan were safety, stability in energy industry with the accordance of cleanliness, and modern technologies (NDRC, 2011). In 2012, the Chinese State Council published a report, which was called *"Policy White Paper"*. That paper mentioned mostly the current situations of energy security and how Chinese government approaches the fact. Even though, the report stressed energy security, no definition or description took place. For stability of energy, domestic supply's importance and efficient usage of energy were underlined as a solution for physical availability of energy in China. According to Liu, *"…energy security system should be presented to guarantee energy supply for a moderately prosperous society by 2020"* (Q.Liu, Q.Lei, H.Xu and et.al, 2018) Additionally, the report mentioned the aspects of social and environmental challenges of energy, however without any connection to the concept of energy security. On the other hand, the paper pointed out a fresh approach to energy security concept, which was called a "mutually beneficial security of energy" for international cooperation (Chinese State Council, 2012).

India is another energy developing country in Asia, like China and Japan. The import dependency in India is an important subject for the Indian Planning Commission. India's 12th Five Year Plan combined new strategies and policies for energy security. As cited from the plan, *"energy security involves ensuring uninterrupted supply of energy to support the economic and commercial activities necessary for sustained economic growth"* (Planning Commission, 2013). Indian authorities emphasized the connection between energy and economic enlargement. Indian officials described energy security through common terminology – uninterrupted supply for energy. The plan also focused on how to decrease the import dependency level of India. As a precaution for import dependency, the plan proposed a new design in the coal market, which suggested opening domestic coal production areas for private companies. Furthermore, the expansion of renewables capacity was noted as a solution. The plan also underlined the impact of universal energy access on the economic developments. It was targeted to supply every single household with modern energy technologies -electricity prioritized- during the period of the Plan. Nevertheless, the Plan explored on the energy accessibility, import dependency and economic growth, without directly centering on energy security. From the environmental perspective, the plan considered renewables, but did not mention the relation between energy security and climate change. The other important action mentioned in the plan was targeting to increase domestic coal production with opening market to private companies.

On the other side of the world, Brazil is one of the most energy rich and developing countries in South America. Increasing energy demand and imports are a big part in the Brazilian energy mix. The Brazilian Ministry of Mines and Energy announced its Ten Year Plan in 2013, which demonstrated the Brazilian government's concerns of energy security on the aspect of supply diversification. The Plan's approach to energy security aligned with the commonly accepted energy security definition. The Brazilian government fulfilled the national demand through affordable prices and increased accessibility of energy in the country (Brazilian Ministry of Mines and Energy, 2013). The plan underlined the importance of domestic supply of electricity and increasing the energy production in the country. Additionally, it mentions the impacts in Brazil's energy policy from local ethanol production and demand from the United States. Apart from the contribution of biofuel in decreasing greenhouse gas reduction and positive impacts on energy security, the plan focused on energy security without adding any social and environmental issues. According to the 2016 International Energy Agency report, electricity was accessible by almost the whole country. This expanded electricity access rate has been a direct result of an adopted program, which was known as Luz Para Todos (Light for All), since 2003. Furthermore, the report highlighted Brazil's potential to be a globally competitive country in the energy market. Ongoing discoveries in new gas and oil sources may transform Brazil into a net oil and gas exporter. That possibility could then help Brazil to control energy security more easily in the future (IEA, 2016).

1.4 Perspectives of Exporting Countries

Since beginning the discussion of energy security, institutions and countries have generally focused on the security of supply issues. The commonly accepted definition was officially endorsed by both the IEA and the United Nations. On the other side of energy transactions, exporting countries describe energy security as steady flow at an acceptable price that can provide economic development and new investments for those countries. The common point of these two approaches is that there should be reasonable price and energy flow needs to fulfill both sides' accepted demand. Exporter countries also emphasize the importance of domestic energy supply. When oil prices collapsed in 1986 it marked the beginning of exporter countries' concerns on energy security. Although this is not officially accepted throughout the energy community, exporters will continue to reference this event because of its significant impacts. During that crisis, most of the exporter countries faced detrimental decline in their oil export revenues. Meanwhile, importer countries tried to reduce their oil dependency. Major oil exporter countries have been dealing with energy insecurity as a result of decreased importer countries demand level – particularly in 1986, 1998, 2009, and most recently in the summer of 2014. In the 2007 Riyadh Declaration, OPEC leaders underlined the importance of the relation between global security of petroleum supply and predictability of demand security. In order to maintain a successful balance, both exporter and importer countries should prioritize these two aspects. In this condition, not surprisingly, exporter countries started to question what was wrong with the importer countries and how they could overcome this situation. For instance, new investments, new production and exportation facilities, and new markets were some of the ideal solutions for exporter countries because they facilitated creating agreements with different countries. Some of the main oil exporter countries have started to apply the methods of OPEC's declaration and gas exporters have tried similar adjustments.

The Gas Exporting Countries Forum (GECF) emphasized the significance of sharing the risks equally among all players in the gas market. The aim was providing a secure market to both the supply and demand sides. Russia is the most dominant and pioneer country among the energy exporters that promotes security of energy demand. In the 2006 G8 Summit, Russian President Vladimir Putin stated that *"measures taken to ensure reliable supplies must be backed up by measures taken to ensure stable demand."* Russian Ministry of Energy published a report as a policy in 2010, the Energy Strategy up to 2030, which focused on energy security as a main strategic guideline for the country. In spite of prioritizing energy security, the plan did not provide any clarifying description of energy security, but instead used the energy security as a guideline. So far, the concerns were on global energy security of demands. The strategy plan underlined the importance of keeping consistent relationships with existing and new countries as an energy partner. European Union is one of the major gas importers for Russia. Liberalization movements in the gas market regarding new policies in Europe and decreasing gas demand as a consequence of Ukrainian crisis caused difficulties for Russia's expected plans. Thus, Russia's concerns were entirely redirected towards demand insecurity in gas trade with Europe. The EU's aim is to create a single domestic gas market, under market liberalization movements. Particularly, the EU's Third Energy Package called for a strong unbundling and powerful third-party access to gas infrastructures with having ownership or as just functionally. Gazprom's current and planned gas infrastructure assets, in and through Europe, are immensely against this concept. As a consequence, Gazprom was forced to decrease export prices to major European importers in order not to lose but maintain existing gas trade. According to BP's statistical review of world energy 2017, Turkey is the second largest gas importer from Russia. Germany is the leading gas importer. Trying to mirror the EU's market liberalization movement, Turkey also tried to find a path to decrease the gas dependency on Russia. Occasionally, Turkey struggled with gas cuts from Russia, especially during hard winter times. Those interruptions on gas flow drove Turkey to find new supplier countries, new roots. Turkey has been importing gas from Azerbaijan, Russia and Iran, totaling 41.1 bcm in 2014 (BP, 2015), with the Russian share being more than 60%. In 2016, Russia's share remained similar in percentage, but Turkey decreased its gas imports by 3.7 bcm through the use of pipelines. That decline was an outcome of Turkey's new energy policy, which has been increasing the share of domestic sources, such as coal, as well as the diversification of gas suppliers. Turkey increased the LNG imports from 2014 to 2016 by 3.2 bcm annually. The two major gas importer countries applied these trends, which elevated Russia's concerns on gas demand insecurity. As a security for energy transit, Russia requested a protection of its current position with importer countries in market regulations (Russian Ministry of Energy, 2014). Similar to Russia, Iran also tried to gain demand security of energy trade. Iran is a member country of OPEC and GECF, an important player in oil and gas trade with its own proven reserves. A study by Iranian government and National Iranian Oil Company (NIOC) mentioned how Iran tried to overcome demand insecurity among the importer countries. Iran offered upstream oil and gas assets to importers in return for demand security of gas markets in Asia. Iranian Petroleum Minister Rostam Ghasemi asserted that in order to have stability in the energy market, all players should focus both on security of supply and demand. One perspective alone cannot suffice to create the optimal situation for energy security (speech at International Energy Forum, 2012).

Shifting to North America, Canada is one of the largest net energy exporter countries in the world. The main exported energy resources are oil, natural gas, coal, and currently shale oil and gas are also gaining importance. Unlike the other referenced exporter countries demand security is not yet an immediate issue for Canada. Its government and National Energy Board define energy security differently than other countries. Energy security refers mainly to protecting the energy infrastructure in the country, rather than focusing on constant flow of energy with affordable price. Another state institution, known as Natural Resources Canada, underlines the importance of using energy efficiently which, in turn, helps to expand energy security. Ironically, the shale gas discoveries dragged Canada into demand insecurity of gas trade along with the United States of America. According to the U.S. Energy Information Administration, the gas exports from Canada to the U.S. progressively declined and are projected to continue to decrease through 2025. As a result of this situation, Canada has committed to expanding and developing LNG facilities for exporting gas to long distance countries. In spite of petroleum producer countries and gas producer countries, the Canadian government has clearly employed a broadened security concept for both energy supply security and demand security issues. It also has promoted the importance of adding energy security in energy policies for each country.

In the past, Indonesia was known as a major oil and gas exporter country; however, it became an oil importer country in 2004 and soon lost its importance in gas trade. Indonesian government aimed to increase domestic energy supply and diversification in its energy mix through 2020, even though plenty of resource reserves were available. Unfortunately, according to BP's reviews of 2015 and 2017, imported oil and natural gas made up only a 60% share of primary energy consumption, even though country's own oil and gas productions are not enough for the demand the Indonesian government targets, according to continuous research by Indonesian National Energy Board focused on a new energy policy strategy, which known as the Indonesia Energy Projection and Energy Policy towards 2050. One of the members from National Energy Board, Dr. Ir Tumiran, highlighted that the availability and affordability of energy should prioritized in energy security actions. Even though there are not any definitions of what was energy security for Indonesia, Pertamina, a state oil company, clarified that energy security is "relate(d) to safeguarding the country's energy future by securing a stable and secure supply of energy at affordable prices" (Pertamina, 2013) – which is very close to importers' perspective. The other energy security issue in Indonesia is the accessibility of energy. According to World Bank statistics, the electrification rate was 73% in 2011, and blackouts became common occurrences even in the capital of the country, Jakarta (Alexandra, 2012). Between 2011 and 2014, the Indonesian government increased the electrification rate to 97% (WB, 2017).

CHAPTER 2

2. Literature Review

There is a wide variety of research studies and projects that have examined energy security. Many different approaches were utilized in these studies, for instance, some of them examined the energy security concept with the perspective of importer countries and/or companies – which, in actuality, is the point of view most preferred overall. The IEA, founded as a result of the 1973 oil crisis, maintains the most widely used definition: *"uninterrupted availability of energy sources at an affordable price."*In other words, energy security relies heavily on these two interrelated, important variables. The former focuses on permanent and incessant flow of energy source, while the latter promotes having an energy source with a reasonable economic condition. There are many similar descriptions and comments related to the understanding of this definition, all emphasizing the importance of these connected variables. In the report 2000, EC indicated that a strong energy security must contain environmental aspects and sustainability together with the classic definition for both persistence and accurate operating of economy. Provided this definition, many research studies expanded upon its intricacies, thus broadening the original scope of consideration. By and large, energy security became based upon maintaining a sufficient, reliable and continuous supply of energy which satisfied the demands of both energy and economy with an affordable and a reasonable price (Jun, Kim and Chang, 2009).

Some countries, authors and organizations understood and handled energy security specifically within the realm security of supply. The security of supply understanding is based on Winston Churchill's oil approach in 1913. Daniel Yergin thoroughly recounts this issue in his book: *"On the eve of World War I, First Lord of the Admiralty Winston Churchill made a historic decision: to shift the power source of the British navy's ships from coal to oil. He intended to make the fleet faster than its German counterpart. But the switch also meant that the Royal Navy would rely not on coal from Wales but on insecure oil supplies from what was then Persia. Energy security thus became a question of national strategy. Churchill's answer? 'Safety and certainty in oil,' he said, 'lie in variety and variety alone'"* (Yergin, 2006).Churchill's decision became a beginning of a new perspective in energy policies for many countries, especially the highly industrialized ones such as, USA, Germany, France, United Kingdom, Italy, Spain, China, Japan and more. After that turning point, countries, agencies and authors were highly focused on energy security and each of them enriched the understanding of its definition, identifying more and newer aspects. According to Nyman, *"The link between energy and national security enables and prioritizes a continued emphasis on domestically produced fossil fuels as central to achieving energy security for the American state, while ignoring the impact on the climate"* (Nyman, 2018).

Security of supply focused on accessibility and availability of energy sources at any time. *"Supply can be disrupted for a number of reasons, for example, owing to physical, economic, social, and environmental risks. The most important crises that have been instrumental in shaping the EU's security of supply policy are of a social and economic nature and were all crises in the GME [Greater Middle East] region."* (Hoogeveen and Perlot, 2007).Despite its origin, generally the term "security of supply" was associated with physical availability of energy sources. Jamasb described the security of supply as *"often discussed in terms of physical availability of energy sources and their commodity price risk"* (Jamasb and Pollitt, 2008). Cherp underlined that energy security is one of the new and powerful subject that can change policies (Cherp, Vinichenko, Jewell and et.al, 2018). Hippel referred the availability as a guarantee for continuity of commonwealth and diminish the possible risks in energy system (von Hippel, Suzuki, and et al. 2011). The reasoning behind this mentality is that availability provides knowledge of the capacity and/or the amounts of the energy source, thus showing how much energy can be produced and/or how much more energy is needed. In other words, Intharak pointed out that the widespread definition comprises three main fundamental elements:

- *"Physical energy security, the availability and accessibility of supply sources,*
- *Economic energy security, the affordability of resource acquisition and energy infrastructure development and*
- *Environmental sustainability, the sustainable development and use of energy resources that ''meets the needs of the present without compromising the*

ability of future generations to meet their own needs" (Intharak, Julay, Nakanishi and et al 2007).

As with any complex topic, multiple variables and viewpoints exist when developing analysis. The risk dimensions detailed above make up only one analytical frame through which to consider energy security. Another common stance involves examining short term and long term notions. All of the risks and uncertainties of uninterrupted flow of energy sources and its physical availability were grouped under short term notion; price policies (affordable, competitive and reasonable), trade agreements and market conditions were grouped under long term notion. Turton and Barreto provide an individualistic approach by considering risks dimensions and time constraints. Admittedly, they acknowledge the fundamental linkages between such variables, but choose to focus their literature on defining them individually (Turton and Barreto, 2005). On the other hand, Le Coq depicted energy security as a continuous availability of energy with purchasable price offers; or in economic terms, energy insecurity can significantly weaken national welfare (Le Coq and Paltseva, 2009). Bohi specified that relationship with these words: *''the loss of welfare that may occur as the result of a change in price or availability of energy"* (Bohi and Toman, 1996).For the relation between energy security and energy policies, Joode emphasized the validity and importance of common definition and combining it with politicians' decisiveness: *"According to politicians, it is guaranteeing a stable supply of energy at an affordable price, no matter what the circumstances. From an economic point of view, however, the concept of security of supply is less clear"* (de Joode, Kingma, Lijesen and et al. 2004).

Another viewpoint focused on the risks caused by insecurity of energy issues. Shortages, brown-outs, transportation and distribution line risks, consumer and market activities, technical issues, regulatory and geopolitical difficulties are some of the types of risks which were considered while developing energy security. According to Scheepers, the main risks refer to shortages of energy supply, *"either a relative shortage mismatch in supply and demand inducing price increases, or a partial or complete disruption of energy supplies".* Additionally, he emphasized and linked together secured energy and consumers' perspective by introducing an uncommon factor and suggesting that "*a secure energy supply implies the continuous uninterrupted availability of energy at the consumer's site"* (Scheepers, Seebregts, and de Jong, 2007). Lieb-Doczy, on the other hand, stressed that the energy security situation must be evaluated through risk and uncertainties as a whole. He underlined the importance of security conditions for energy by stating that *"more secure systems are those with lower risks of system interruption"* (Lieb-Doczy, Börner, and MacKerron, 2003). These instabilities of energy security guided countries and researchers to find solutions to control and manage them. The risk management approach examined risks under five categories which are directly related with the energy supply chain:

- Supply and production,
- Transportation lines,
- Distribution network,
- Consumption and market activities and
- Waste disposal management.

Each of the risks mentioned above is related to one of those categories and which make up the natural process of energy. According to Keppler, *"[t]he risk management approach to the security of energy supplies argues that supply security is an issue dependent on the risk-adverseness of consumers, which varies widely between countries. Other things being equal, American consumers prefer lower prices and relatively higher risk, whereas European customers prefer higher prices and relatively lower risk,"* highlighting consumer approaches from different perspectives (Keppler, 2007).

In spite of energy security being originally based on oil supply security, new discoveries and extractions methods ultimately led to natural gas becoming popular all over the world. Especially after the Second World War, with new techniques and technological developments, natural gas gained importance and pipelines began to expand. Due to these improvements in the energy sector, supply security started to mostly focus on continuous supply of natural gas, economical balance and a variety in supplier. For example, Noel mentioned a common understanding of the energy security notion in that *"'security of supply' (or gas supply security) refers to the ability of a country's energy supply system to meet final contracted energy demand in the event of a gas supply disruption"* (Noel and Findlater, 2010). In other words, some authors defined natural gas security in terms of preventing the deduction of natural gas as an insurance measure within the security policies. Stern defined security of natural gas with two major risks:

- *"short-term supply availability versus long-term adequacy of supply and the infrastructure for delivering this supply to markets;*
- *operational security of gas markets, daily and seasonal stresses and strains of extreme weather and other operational problems versus strategic security, i.e. catastrophic failure of major supply sources and facilities* "and also emphasized by Spanjer, which is the importance of diversification the gas suppliers (Spanjer, 2007; Wright, 2005; Stern, 2002).

Furthermore, policy makers' consideration of energy security is comprised of constant flow of energy sources and the economical conditions. Energy market consumers' role in the energy security is also involved in the situation. In Joskow's research, he underlined the understanding of policy makers in that *"first, they are concerned about 'involuntary rationing' of demand,"* which includes blackouts, transmission and distribution network breakdowns and the negative impacts of each. *"Second, policymakers are also concerned about high prices or at least sudden increases in prices, for electricity and natural gas that naturally emerge to balance supply and demand when supplies are 'tight'"* (Joskow, 2005). In other words, policy makers are simultaneously concentrating on external and internal factors of energy security, in order to facilitate the highest level of stability. According to Sovacool, he mentioned the perspective of energy security is more important than just saying or touching "*building infrastructure, developing energy resources, forecasting future energy demand, or conducting research on new technologies…"* these parameters of energy (Sovacool and Dworkin, 2015).

Some literature studies of energy security argue that research should be segregated into two major sections, with one focusing on the relation between energy security and economical issues, and the other stressing the importance of political and strategic perspectives of countries. According to Checchi, *"the literature is further divided between those who see the security of supply as exclusively related to energy and those who like to couple it with the environmental dimension. Although there is no common interpretation, it is possible to identify number of features that are always included, namely physical availability and prices"* (Checchi, Behrens and

Egenhofer, 2009). According to Mey, in order to have a successful energy security plans in energy policies, policymakers should consider three important points.; *"direct actions to reduce energy consumption, development of an energy strategy with recent reports and change of the regulatory framework"* (Mey and Diesendorf, 2018). That division is very evident throughout the literature review. Even though it is believed that most political views are not disconnected from an economic perspective, they often focus on the real flow from supplier countries. Patterson emphasized this by stating from a political perspective, that *"the energy security that worries politicians' concerns supplies of imported oil and natural gas, not the secure delivery of energy services, such as keeping the lights on"*(Patterson, 2008). According to Mulder, politicians generally refer to the common definition of energy security, which is the constant flow of energy with affordable prices at all conditions. While stressing the relationship of economical perspective with security of supply, he indicated the importance of energy markets by underscoring that "*the concept of security of supply is related to the efficiency of providing energy to consumers. Markets will always show variations in supply and demand and, hence, in prices. A reduction in supply puts upward pressure on prices, thereby curbing demand, and an increase in demand raises prices and thus encourages an increase in supply."*(Mulder, ten Cate, Zwart, 2007).

Security of supply became one of the top issues within both national and international policies around the world. Additionally, policymakers identified some new sub-criteria as part of this aspect, which should not be neglected when energy security is the issue. Generally, source availability, demand, supply and price balance are the most underlined dimensions of energy security. Grubb defines security of supply as offering *"a flow of energy to meet demand in an economy in a manner and price that does not disrupt the course of the economy,"* and similar to this common description, he highlights that risks are mostly gathered around of supply interruptions, transmission/distribution breakdowns, electricity shortages (brown-outs) and sudden price fluctuations (Grubb, Butler and Twomey, 2006). Geng proposed a new model of energy security which consisted of four dimensions *"such as energy external availability, affordability of energy import, energy technologies and energy efficiency and energy resource reserves"* (Geng, Ji, 2013). Kruyt presented a supportive idea, which had been evolving throughout the years, and described the elements of energy security as *"availability or elements relating to geological existence, accessibility or geopolitical elements, affordability or economical elements"* (Kruyt, van Vuuren, de Vries and et al., 2009). Pajak underlined the importance of smart grids, "*in order to increase energy security and reduce energy losses the improvements and functioning network system has an impact over transmission and distribution lines"* (Pajak, Kvilinsky, Fasiecka et.al, 2017).

In another viewpoint, some authors claimed that inevitably risks are changing and getting harder with the variety of scope, in the energy security issues. Security of supply was the first focused dimension and it begun with oil supply, then through developments in the energy sector natural gas gained importance. Meanwhile, some other aspects were included to energy security understanding. For instance; policies, regulations, demand insecurity, energy market potential, capacity issues, shortages, disruptions, end-users perspective, were all considered by authors/agencies as one of the elements of the energy security. In addition, also some new concepts were added to the list in order to analyze the issues exhaustively. According to Narula in order to enhance, "th*e energy security by paying attention to energy markets, national energy efficiency and lower carbon dioxide emissions"* are three important subjects (Narula, Reddy and Pachauri, 2017). One of them is separating the process of energy into two; short-term and long-term activities. Uninterrupted and permanent flow of energy from suppliers to demanders, in other words the physical availability of source is counted as short-run activities. Affordability prices of the flow, purchasable offers for end-users, price fluctuations, agreements and deals are the main objectives of long-run activities. The other one is the core fundamentals of energy security, such as; physical, economical, social and environmental availabilities of energy. Some of the authors are combining social and environmental issues together and listing the elements is in three. According Lesage, current definitions of energy security is not answering some issues in the energy area such as " *the notion 'security' does not capture the pollution problem very well, nor the social distribution problems within the countries"* (Lesage, van de Graaf and Westphal, 2016). There is a similarity between short/long term analysts and main fundamental analysts. The physical availability covers the risks which are in short-term activities and price issues which are in long-run activities also covered in economical availability. Furthermore, by developments and improvements in energy sector, some authors stressed out new terminologies and renamed some existing elements of energy security. For example, availability, affordability, geopolitical risks, accessibility, supply/demand ratio are one of the most underlined dimensions. Moreover, the authors who are asserting that variables, fundamentals and factors which are mentioned above in the scope energy security, all are answering the risks and uncertainties but the questions;

- "security for whom",
- "security for which values",
- "from what threats",

Should be added into list of understanding the energy security, in order to clarify and examine these perspectives. According to Baldwin, who is in accord with a well-known security researcher, Barry Buzan, general understanding of security is not answering the question "security for whom?" The simple definitions' "the state" and "individuals" are superficial to evaluate the security issues because there are plenty of states and individuals which their security interdependent to each other. Buzan stated that "'*search for a referent object of security' must go 'hand-in-hand' with that for its necessary conditions"* (Baldwin, 1997; Buzan, Waever and de Wilde, 1998). In the viewpoint of Cherp, all research questions were asked to analyze and examine the energy security issue in any of its aspects/dimensions. Despite these various and many other approaches, he stated that *"the four A's [availability, accessibility, affordability, acceptability] do not answer or even ask 'security for whom?' most likely because this question is not explicitly present in classic energy security"* (Cherp, Jewell, 2014). The common definition came in view after the industrialized countries begun to search new and different alternatives for both energy source and suppliers. They were just focused on oil importing process at that time. For today's energy sector, things became more complicated than beginning. That's one of the reasons for some researchers to study the relations energy security with those questions. Unlike mostly focused perspectives (state based), Bridge's approach, which is emphasizing the new factors in energy security, underlined the existence of players in energy sector and collaboration with consumers (Bridge, 2008).

The four A’s were interpreted differently as a result of various viewpoints by authors and dimensions of energy security. For instance, the affordability defined by Geng as the risks and fluctuations in the import process of crude oil (Geng, Ji, 2013). Whereas, one of the other perspective was focused on low price offers for end-users. Asia Pacific Energy Research Centre’s (APERC) report in 2007, described the affordability in energy security as where countries gain profits from the energy investments, where Sharifuddin argued that the affordability covers energy intensity and diversification in the market alongside with price uncertainty (Sharifuddin, 2013). In addition for interpreting one of the other element of four A’s which is acceptability, generally authors and energy sector made reference it to environmental effects of energy. In actually, under the continuous changing conditions in energy sector, environmentally acceptability consist more than one actor such as; population, industries, ecological non-governmental organizations, state policies. In some other approaches, social risks counted together with environmental aspects as in Hoogeveen mentioned EU’s security of supply policies (Hoogeveen F. and Perlot W., 2007). In general, researchers/authors focused to study energy security in some aspects and tried to find new methods or evaluate the applicability of existing theories of energy security. According to Chester, a universal definition for energy security with all variables of its, something not possible because of each countries has its own circumstances (Chester, 2009). In order to overcome this issue some authors preferred the surveys and interviews method, to collect the individual understanding of energy security and construct the energy security mentality on the results (Sovacool and Mukherjee, 2011). According to Cherp, that could cause new difficulties and such method could *“blurs rather than clarifies the distinct priorities of different actors”* (Cherp and Jewell, 2012). The argument, which is four A’s are not enough to analyze and examine entire energy security situation in different countries under various conditions with plenty of energy dimensions, emphasizing the lack of clearness in the classic definition.

Second question, which is “security for which values”, stands for to expand four A’s perspective. By all means the four A’s concept associated with the political, economical, social and environmental dimensions of energy security. In literature, no doubt each author focused on different approaches of the issue. For instance, Daniel

Yergin is one of the supporter authors for the classic definition, with underlining relation oil and energy sectors since the idea was first mentioned. Hoogeveen and Jamasb mentioned the four dimensions as one of the risks when they considered the energy security (Hoogeveen and Perlot, 2007; Jamasb and Pollitt, 2008). Meanwhile, Bohi and Le Coq examined the economical dimension with state's welfare, where some other authors stated the terms in the short and long run for energy security. Kruyt and Geng were two representatives of four A's in energy security literature.

On the other hand Cherp and Jewell, who mainly concentrated on that four A's are limited to explain energy security issues, unless the three questions which they claimed that those are needed to be add on energy security literature and researches for easily clarifying the concept. According to them, it's not so clear when political, economical, social and environmental dimensions of energy security tried to be analyzed with the four A's concept, even though both approaches are nested together in the energy security issues. In their viewpoint, so as crude oil was the beginning of energy security, mostly countries and studies concentrated on that relation. The sectoral improvements and technological developments enriched the understanding of energy security. In addition, Cherp stated that *"[four A's are] failing to answer a central concrete policy question: 'which energy security systems to protect?'"* and described that as a key factor to build up the common understanding. Thus, they asserted that *"The four A's are not suited for designing such metrics or informing such policies because they are unclear about the values to protect, the energy systems to which they apply, and the links between the two"* (Cherp and Jewell, 2014).

The perspective of the third question, which is "from what threats", inquire to indicate deficiency of four A's. Availability generally related with physical existence of energy source, affordability point outs the term of economical issues, accessibility underlines usability of energy source and acceptability considers as the social-environmental concerns by majority of the energy security literature. Some new concepts such as: risk and resilience are not evaluated by the four A's approach. This concept generally focuses on system weaknesses, infrastructure disruptions, terrorist attacks and more. For instance, according to Johansson, *"the importance of diversity for reducing the vulnerability of the system to price changes will depend on how correlated prices for various energy sources are on the market and how vulnerable* *the study entity (country, industry, household) is to fluctuating prices"* where he indicated the meaning of diversification in the energy system (Johansson, 2013). Meanwhile, Lilliestam examined the European vulnerability on terrorist attacks with highlighting the imports of natural gas and electricity (Lilliestam, 2013). Farrell's approach was centered the infrastructure elements and its effect on energy security (Farrell, Zerriffi and Dowlatabadi, 2004). Cherp stated that *"a concept of energy security cannot list all possible risks or vulnerabilities, but it should provide a framework for identifying, measuring and managing vulnerabilities"* which is actually they added three questions for expanding the existing approaches of energy security (Cherp and Jewell, 2014).

Within the literature review, the most results obtained by two different sources. First, Science Direct database, there are over 13.500articles/studies related to the keyword "energy security," all conducted in 2017 alone. Using the same search criteria in another source, Google Scholar, one can find over 38.000 articles/studies. This literature survey covers various energy security studies from these two over-arching libraries. They are detailed and listed in an excel table to form the background of the study. They include papers from peer reviewed journals, and reports of national agencies, international organizations and businesses, and professional associations. The main journals are Applied Energy, Energy, Energy Policy and Renewable and Sustainable Energy Reviews. Examples of reports are those of The International Energy Agency (IEA), The World Bank (WB), and the Institute for 21st Century Energy of the U.S. Chamber of Commerce, The European Commission (EC), World Economic Forum (WEF), World Energy Council (WEC) and more. Those studies and reports were separated and listed into 3 categories: keywords, objectives, and main indicators (i.e. dimensions, variables used or identified). The first includes sources related together through common "energy security" vocabulary. That is obvious to figure out which concepts are forming the common approaches of energy security from the most used keywords. The top five of them:

- "energy security"
- "energy policy"
- "energy security index"
- "4A's"

- “Security of supply”

The objectives portion highlights how the authors discussed the “energy security” concept in its entirety, defined the essential topic, and approached each analytical process. For instance, some authors preferred to utilize common or some other authors’ perspectives, like Andrews, he stated that, *“I use Yergin’s definition: 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’’* (Andrews, 2005). On the other hand, some others reinterpreted the classic definition in order to expand and enrich it. McCarthy indicated that *“the degree to which the primary energy system is secure against threats to global supply infrastructure”* for energy security (McCarthy, Ogden and Sperling, 2007). Moreover, some studies focused on particular aspects of energy security, for example Ölz highlighted that *“energy security risk as being the degree of probability of disruption to energy supply occurring”* for a report of EIA (Ölz, Sims and Kirchner, 2007) where they focused on possible risks of energy security and renewables role to manage the risks. According to Hawkey, in order to increase energy security the usage of renewables must be increased for having low carbon emissions at first urban scale (Hawkey, Webb, Lovell et.al, 2015).

Lastly, the main indicators category consists of the different dimensions and methods of how these studies examined the energy security concept. Literature review, regional energy security assessments, analyzing energy security situation for specific countries, surveys to indicate the perspectives of different players in the energy sector, applying mathematical methods to examine the conditions, these are some of the methodological approaches in the list. Furthermore, there are thirty-two different indicators listed in excel table from the different studies, some of which focus on similar or close issues, thus they are collected under related sub-categories. More specifically, the EC’s report from its Joint Research Centre (JRC) emphasized that under two categories one includes simple indicators and the other one is for composite indicators.

Table 1: European Commission Energy Security Indicators

Simple Indicators	Composite Indicators
Energy Resource Availability	Supply / Demand Index
Accessibility Barriers	Willingness to Pay
Investment Cost Affordability	Oil Vulnerability Index
Environmental Acceptability	Vulnerability Index
Energy Intensity	
Energy Dependency	
Energy Price	
Sectoral Indicators	

Source: European Commission Report, 2010

In total, there are twelve indicators related to energy security. This study accounts for the overall thirty-five indicators and acknowledges the EC's twelve indicators, but focuses solely on eight explicit indicators for the sake of simplicity. In the table 1, exhibited that the list of eight indicators which are elaborated in the chapter 3, which is "Indicators of Energy Security".

In the literature review among the various studies many different countries and organizations included into them. Regional perspectives, country based analysis, interrelated countries and their interactions on energy issues are some of the approaches while searching energy security conditions. Fifty-five countries, except them, OPEC, OECD, EU, UN and ASEAN organizations involved in the articles. Eleven of the articles were focused the topic "energy security" as a general issue and studied on different and multiple countries at the same time. Twenty-five of the articles examined and or analyzed energy security as a concept and not including countries. Few articles selected particular parts and regions of world such as; "Aegean Islands", "Baltic States", "East Asia" and "Middle East and North Africa (MENA)" are the popular ones. In table 2, it is exhibited that the most analyzed countries under the scope of energy security. The list covers top fifteen subjects of analysis.

Table 2: Most preferred countries and regions in the excel table

Literature Review	25
European Union	16
China	16
Worldwide	11
Japan	10
South Korea	7
India	7
Brazil	7
Russia	6
Turkey	6
USA	6
UK	6
Germany	5
Singapore	5
ASEAN Countries	5

CHAPTER 3

3. Indicators of Energy Security

The concept "energy security" had begun only focusing diversification in oil supply of the countries and long years that understanding continued. Energy is always a sector which is dynamic, incessantly developing and improving area. That was the main reason that energy security fundamental did not restricted only with the variety in oil supply. Many studies and research which cover energy security have done and maintaining. Some of the studies focused on the origin of the concept, and some other studies highlighted the new sides of energy security. The common definition of energy security, which is underlined by many organization and authorities in the sector, that focuses on the two essential anchor of energy. Physical availability of energy sources at an affordable price conditions for the countries. For instance, The World Bank's (WB) definition of energy security, which is *"ensuring countries can sustainably produce and use energy at reasonable cost."* Although there are numerous definition of energy security from different authors, institutions and agencies, all are connected to main and common one. New and improved definitions brought new perspectives and indicators. These are the sub-indicators with main 4A's (Ren and Sovacool, 2014).

Approximately there are some similar results with the research of Sovacool, in the table 3. Even this partial similarity is a minor evidence for more or less the all energy security studies based on few common indicators and each new added one is a kind of branches of a tree. In majority, availability refers to the sufficiency of energy source, both as a natural resource or in the energy market. On the other hand, some approaches apply availability for the adequacy of primary energy supply and energy imports. The common understanding of this indicator is, if there is high level of availability that minimizes the possible risks of supply disruptions. Affordability, which is directly related with the economical perspective of energy security, has its main connection with the imports and possible budget deficit as a result of these imports. Acceptability mostly related with the environmental issues and mainly utilized for both CO2 and Greenhouse gas emissions and the infrastructure issues for power plants. In general, accessibility indicator is dealing with the issues both source and resource accessibilities and end-user access to grid (Narula and Reddy, 2015).

Figure 1: Excel table for indicators from literature review

Authors, Years	Availability	Affordability	Accessibility	Acceptability	SoS*	Energy Mix	Diversification	Dependency	Emissions	Intensity
Cherp (2014)	*	*	*	*	*					
Rasul (2014)	*		*	*	*					
Ellabban (2014)	*		*	*	*				*	
Jewell (2014)	*	*	*	*	*	*	*	*	*	
Hawkey (2015)	*	*	*	*		*	*	*		*
Sovacool (2015)	*		*	*						
Müller-Kraenner (2015)	*	*	*	*	*					
Ang (2015)	*	*	*	*	*	*	*	*	*	*
Aalto (2016)	*	*	*	*	*	*	*	*		
Collins (2016)	*		*		*					
Lesage (2016)	*	*	*	*	*	*	*	*	*	*
Bogdanov (2016)	*		*		*			*		
Zhou (2016)					*	*	*	*		
Durant (2017)	*	*	*	*			*	*		
Khanna (2017)	*	*	*	*	*				*	
Bohi (2017)	*	*			*	*				
van Vliet (2017)	*		*	*	*					
Pajak (2017)	*	*	*	*	*		*	*		*
Radovanovic (2017)	*	*	*	*	*		*	*	*	
Sharma (2017)	*		*	*			*	*	*	
Jacobson (2017)	*		*	*	*		*	*	*	
Uyar (2017)	*		*	*	*		*	*	*	
Narula (2017)	*				*		*	*		
Chandler (2018)	*	*		*			*		*	*
Tarasova (2018)	*		*	*	*		*	*		
Moallemi (2018)	*	*	*	*	*	*	*	*		
Delina (2018)	*	*	*	*	*	*	*	*	*	
Liu (2018)	*	*	*	*	*	*	*	*	*	
Palestini (2018)	*	*	*	*	*	*				
Chen (2018)	*	*			*		*	*		*
Shuba (2018)	*		*	*		*			*	
Cherp (2018)	*	*	*	*	*					
Sperling (2018)	*	*	*	*	*					*
Kay (2018)	*	*	*	*	*					
Mori (2018)	*	*	*	*	*	*	*			
Mey (2018)	*	*	*	*	*		*			
Nyman (2018)	*		*	*			*		*	
Burke (2018)	*	*	*	*	*		*		*	
White (2018)	*		*	*	*	*				
Amegroud (2018)	*	*	*	*	*	*	*	*	*	*
Delina (2018)	*	*	*	*	*		*	*		
Dai (2018)	*		*	*	*		*			
Kabir (2018)	*		*	*	*	*	*		*	
Saini (2018)	*	*			*	*				

Authors, Years	Availability	Affordability	Accessibility	Acceptability	SoS*	Energy Mix	Diversification	Dependency	Emissions	Intensity
Greene (2010)		*			*			*		
Jansen and Seebregts (2010)		*		*	*		*			*
Skerlos and Winebrake (2010)				*					*	
Lefevre (2010)	*	*		*		*	*			*
Apergis (2010)	*		*			*	*		*	
Bradshaw (2010)				*			*	*	*	
Bang (2010)					*	*	*		*	
Frondel (2010)	*	*				*	*			*
Vivoda (2010)			*	*	*				*	
Umbach (2010)		*			*					*
Löschel (2010)	*	*	*	*			*	*		
Sovacool (2010)		*			*		*	*		
Bollen (2010)			*	*			*	*	*	
Reid (2010)				*	*				*	*
Ciuta (2010)	*	*		*		*	*	*		
Chester (2010)	*	*	*	*			*	*		
Menyah (2010)	*			*	*			*	*	
Goldthau (2010)	*		*	*			*	*		
Stokes (2010)	*			*	*		*		*	*
Sovacool (2010)	*	*	*	*			*	*	*	*
Yergin (2011)	*	*	*	*	*		*	*		*
Sovacool (2011)	*	*	*	*			*	*		
Pandley (2011)		*			*					*
Leung (2011)	*		*				*	*		
Sovacool (2011)	*	*	*	*						
von Hippel (2011)	*	*	*	*			*		*	*
Cohen (2011)	*		*				*	*		
Cherp (2011)	*	*	*	*	*					
Sovacool (2011)	*	*	*	*	*	*	*	*	*	*
Clastres (2011)	*	*		*		*			*	
Corner (2011)	*		*	*			*			
Bohi (2012)	*	*				*	*	*		
Bakker (2012)	*	*		*					*	
Goldthau (2012)	*	*	*	*						
Winzer (2012)	*	*	*	*	*	*	*	*	*	*
Williams (2012)	*	*	*	*	*					
Carvalho (2012)	*			*	*		*		*	
Vivoda (2012)	*	*	*	*	*	*	*	*	*	*
Ratner (2013)	*		*	*			*	*		
Johansson (2013)	*	*	*	*			*	*		
Maltby (2013)	*	*	*	*						
Johnson (2013)	*		*	*		*	*	*	*	
Bizikova (2013)	*		*	*	*					
Andrews-Speed (2014)	*	*	*	*			*	*	*	*

In total eighty-eight article examined in the literature review. The dimensions and indicators for energy security grouped under ten main headlines. The main widespread understanding is the 4A's of energy security. Availability, Affordability, Acceptability and Accessibility of energy are the main indicators for general approach to energy security. According to Sovacool, the main 4A's are composed by sub-indicators. Considering to his study;

Table3: 4A's and sub-indicators

Availability – A1	**Affordability – A2**
• Security of Supply	• Price stability
• Self-sufficiency	• Dependency
• Diversification	• Market liquidity
• Renewable energy	• Decentralization
• Technological maturity	• Electrification
Acceptability – A3	• Equity
• Environment	**Accessibility – A4**
• Social satisfaction	• Import stability
• National governance	• Trade
• International governance	• Political stability
• Transparency	• Military power
• Efficiency	• Safety and reliability
• Innovation	
• Investment and employment	

In particular for this study, the eight selected indicators' utilization will be under these conditions. These indicators will be used to analyze both selected African countries and benchmark countries' historical developments and current situation of energy security in chapter 5 and 6.

- Availability is measured as Proven Reserves
- Affordability is considered as Electricity price for household users
- Acceptability is handled as CO2 emissions and current related policies
- Accessibility is considered as Share of population who has access to electricity
- Dependency is measured as Import and Export balance accompaniment with overall production and consumption balance

- Diversification is handled as Total primary energy consumption by fuel types
- Energy Intensity is considered as MJ/$2011 PPP GDP
- Sectoral Indicators is measured as The overall consumption dispersion by sectors

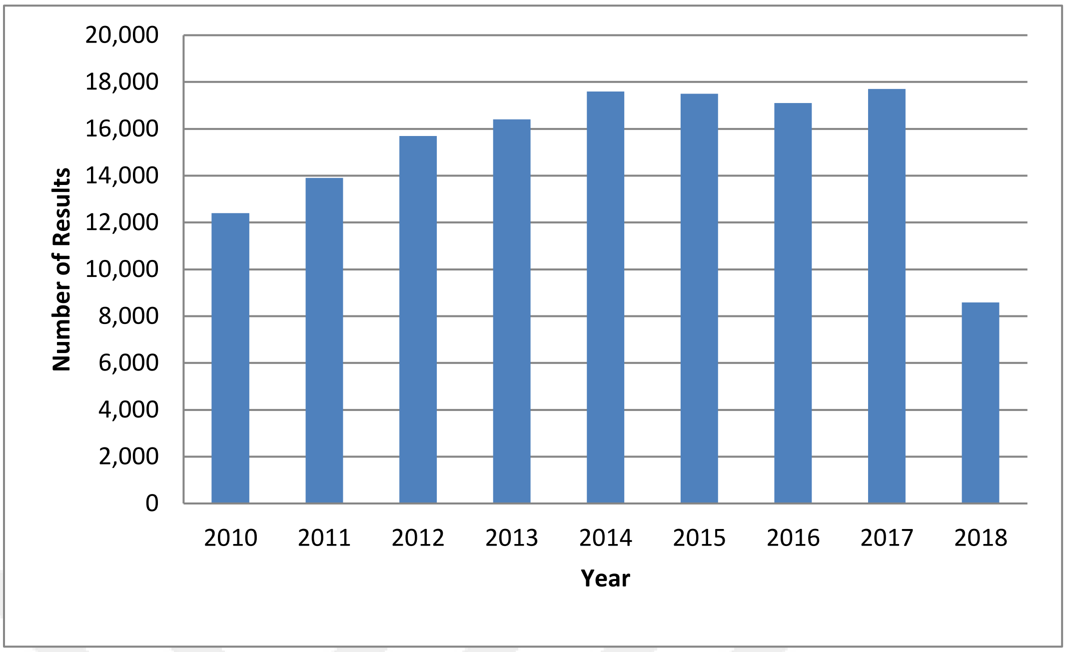
CHAPTER 4

4. Methodology

In this study, energy security situation analyzed for selected African countries under the correlation between the historical evolve of energy security and previous studies and researches. In the beginning, a smooth guideline was drawn for historical changes of energy security since the starting point from early 20th century, in the chapter 1. It mainly focuses how energy security appeared first and what was the understanding and how it was changed in the process. Then, study examined the existing studies, research and reports of energy security from numerous sources, authors and agencies. General approaches, most used indicators and most analyzed countries are listed in an excel table after the literature review and in the chapter 2, all of them are taking place with tables and with elaborated expressions. In chapter 3, there are definitions of indicators which are mentioned in previous chapter and tables, figures to demonstrate the common approach by studies from different sources of energy security indicators.

For the literature review, this study utilized Google scholar database to reach the articles and the studies about energy security. With three different criteria the articles were chosen and examined for this study. First of all, in order to keep up-to-datedness the year criteria was limited in between 2010 to 2018. Google scholar provides an option to list the articles from most relevant to least relevant with searched keyword, so relevancy is the second criteria. Citation amount of articles were the third criteria for the research. From 2010 to 2016, the articles which had more than hundred citations were selected. For 2017 and 2018, the citation amount criteria was more than ten, because the published articles are so new and there were few articles which have more than hundred citations. Research Gate, Science Direct, IOP Science, Taylor and Francis Group and MDPI websites, databases are the most used sources with Google Library. “Energy Security” keyword is the main research point for this study. In the Google Scholar search engine, on the left column where the criteria options selected, if you choose from 2010 to 2018 as a custom range for year criteria, the result shows that 72.400 articles/studies related to our searched keyword. Following table demonstrates the dispersion of the years.

Table 4: Numbers of Articles of related to Energy Security in Google Scholar



Searched keyword "energy security" and the results were 136.880 articles in total. As it can seen, there is a continuously increase of the related articles with the subject. In order to underline how the importance of energy security evolved, this steady increase in the numbers of articles is one of the evidences. Security of supply, 4A's – together and individually- accessibility, availability, acceptability and affordability of energy and energy security index are the other keywords utilized for this study. On the other hand, there are many journals utilized by the search from Google Scholar, for instances; "Energy Research and Social Science", "Energy Policy", "Global Environmental Change", "Applied Energy", "Energy Strategy Reviews", "Renewable and Sustainable Energy Reviews" and "Sustainable Energy Technologies and Assessments" are the most used ones, in total twenty different journals and their publications examined for this study.

In this study, meanwhile examining the energy security situation of selected African countries by the selected indicators from literature review analysis and current studies of energy security, in addition benchmarking also utilized to find out more results, more details of energy security and to draw a guideline for African countries. According to Strategic Management Insight (SMI), *"Benchmarking is a strategy tool used to compare the performance of the business processes and products with the best performances of other companies inside and outside the industry."* In this study, benchmarking applied to countries and their energy security situations with specific indicators, in other words African countries and selected three other countries approaches to energy security and current conditions of energy security indicators of them analyzed and examined with the philosophy of benchmarking. In order to be more explanatory, according to business perspective, the companies need to know and understand what are the other players in the market are handling the situations in the sector, what they are doing? , how they are reacting against the troubles? There are many whats and hows to understand and keep your company successful or check the current situation that you perform well or do you need to improve yourself to compete with your rivals in the market (SMI, 2017). In this study, the approach is not to find out or create a competition in between the countries, the main aim is examine the countries with benchmark countries (Norway, Australia and Kazakhstan) and try to obtain an optimal guideline for each African countries under the perspectives of the current well doing countries –which have more or less similar conditions with them-.

According to Salluh and Tasopoulou, there are many different types of benchmarking approaches but the most commonly recognized one covers;

- ***"Process**: Evaluates specific business processes (e.g., purchase planning, e-procurement, service delivery). Process maps are used to facilitate benchmarking.*
- ***Performance:** Compares product and service as a way to assess the organization's competitive position against same-sector peers. Focuses on costs, technical quality, ancillary service features, and performance characteristics (also called competitive benchmarking).*
- ***Strategic:** Seeks to evaluate the organization's strategic maturity against others across various sectors. Focuses on general approach to the development and management of core competencies, innovations, and change strategies."* (Tasopoulou and Tsiotras, 2017; Salluh, Soares and Keegan, 2017).

These three ground points are the main applied benchmarking approach by the companies or agencies in any sector. Pfaff pointed out that seven different benchmarking types which are process, product, strategic, internal, competitive, functional, and generic benchmarking (Pfaff, Neubig and Krcmar, 2017).

Furthermore, Salluh underlined that with benchmarking system both quantitative and qualitative results can be gained. Usually process of benchmarking has four steps;

1. Planning
2. Analysis
3. Action
4. Review

In this study the first step covers, identifying and determining resources, indicators and the countries. Following step, collecting data sets for indicators and countries then examining them together in order to find out the current situations of the countries, Third and fourth step is together to analyze and try to create a guideline for countries from where the results obtained in the step two. According to Bogetoft and Otto, benchmarking can be utilized for many various backgrounds; intra-organizational comparisons, inter-organizational comparisons and lastly longitudinal – panel or dynamic- comparisons. In this study the applied benchmarking is one of the adapted versions of in longitudinal comparison, which is an approach to analyze the situation between one or more subjects in the same issue. In other words, *"...where the performance of one or more firms in different time periods are compared..."* (Bogetoft and Otto, 2010) There are more than three thousand articles/studies related to energy and benchmark analysis from 2010 to 2018. Benchmark is one of the preferred methodologies when comparative analysis applied to energy studies.

The African countries were selected to analyze specific parts of Africa. Algeria is a representative of Northern Africa and key player of natural gas industry in the continent. Egypt represents the Northeast of the continent and transitions of the fossil fuels in the overall energy mix. Nigeria stands for the main producer of crude oil and symbolizes the west side of the Africa. The last country is South Africa, which is the largest coal producer and only country that utilizes nuclear power in the continent. Even though the Africa has six regions; north, west, south, east and central, in order to be consistent with all indicators and main players of regional and continent scope, only north, west, south and northeast (at least to have a country from east side) of the continent selected. They were analyzed in the chapter 5. Three countries chosen from different parts of the world, to compare and find out the positions of selected African countries in the world. Australia is for coal and natural gas production, Kazakhstan is for oil production and Norway is for resource transition of fossil fuels, in chapter 6.

African countries are selected as a representative for each region and all selected ones are representing also an energy source. North, South and West of Africa are representing by Algeria, South Africa and Nigeria in order. Only Egypt is the country represents northern east of the continent, since any eastern country –like central region countries- lack of sufficient data sets for existing indicators. According to BP data sets, Nigeria had 5 thousand million tones of proved oil reserves at the end of 2016 and, their oil reserves to production ratio (R/P) was %49.3. There are many countries in the world some of them have more reserves and some of them have less reserves than Nigeria but in this study Kazakhstan selected as a benchmark country for Nigeria because more or less Kazakhstan have similar values with Nigeria. The country has 3.9 million proved oil reserves and its R/P was %49 at the end of 2016. Even though there are also twenty-one other possible oil countries in the BP data sets; USA, China, Qatar or Brazil are just one of the other possible countries. The dominance of crude oil production and exportations in both countries are similar like their R/P ratio. Unlike this selection strategy which applied for Nigeria and Kazakhstan linkage, for South Africa/Australia and Algeria – Norway pairing for benchmark analysis, other criteria also taken into consideration, geographical positions of each country and their pairs. South Africa and Australia are one of the coal producing and exporting countries in the world. Their reserve amounts or other values are not similar but advantage of their geographical location provides them to export in both by sea and road routes. South Africa has coastlines to both Atlantic and Indian Ocean meanwhile; Australia has coastlines to Indian, Pacific and Southern Ocean. For Algeria – Norway linkage, their main focus point is natural gas and its trade. Although, Algeria’s proved reserves almost 2.5 size more than Norway’s, their export amounts are just opposite values. In actuality, their main export points are in Europe, which Norway is in the north and Algeria in the south of the continent. Russia and Netherlands may be their big competitors for exporting natural gas to Europe. Algeria had 4.5 tcm proved natural gas reserves, Norway had 1.8 tcm at the end of 2016. In brief, proved reserves, R/P ratios, geographical locations and the policies which benchmark countries applied for their country in order to decrease fossil fuel dependency and increase energy security levels in the country are the criterias that Kazakhstan, Norway and Australia selected to compare with African countries to find out an optimal guideline for each country for energy security situations (BP, 2017).

The countries and indicators are connected with three research questions which for to analyze and examine the energy security situation. The questions are;

- Where the selected African countries' energy security positions are located in the world?
- What are the common and different points of the selected countries in between?
- What are the common and different points between African countries and benchmark countries?

Answers for these questions are in the chapter 7, which is findings and conclusion part of the study. In addition, there are also some future projections and small advices for selected African countries.

CHAPTER 5

5. Selected Countries from Africa

Algeria, Egypt, Nigeria and South Africa are the selected ones from the continent. The main focus was having countries from all regions. The Africa has five regions; north, south, centre, east and west. For the determined indicators in the chapter 2 and 3, all countries were scanned by sources, which are the origins of data sets. It was intended to be that have countries from all regions but few of them fulfilled the indicators. Algeria is the representative of Northern Africa and also one of the net producers and exporters of natural gas in the world. Nigeria is the main oil producer and export in the country and stands for Western Africa. South Africa is the only one utilizing nuclear power plants and one of the net producers and exports of coal, represents Southern Africa. Egypt uses its natural gas and crude oil reserves; also the country switched the resources in their primary energy consumption. None of the Eastern countries have enough sources for indicators, due to that Egypt is selected as a representative from North East of the continent (IEA, 2017).

The countries examined with selected indicators in an order to exhibit what is the current situation of them. Firstly, with general information of country and its primary consumption with percentages are demonstrated in the pie chart. Then, current reserves of countries and the numbers of hydro power plants or other renewables analyzed. Secondly, production and consumption amounts and historical developments of the energy sources, which the country utilizes most, examined with excel chart. Afterward, the import and export amounts, sectoral consumption by fuel types, energy intensity and carbon emission levels are analyzed by charts. Lastly, electricity access of the countries demonstrated with charts, pricing method for residential users in the country examined by reports. This order of indicators were applied because to indicate more clear and step by step the energy security relations. On the other hand, countries are analyzed in an alphabetical order.

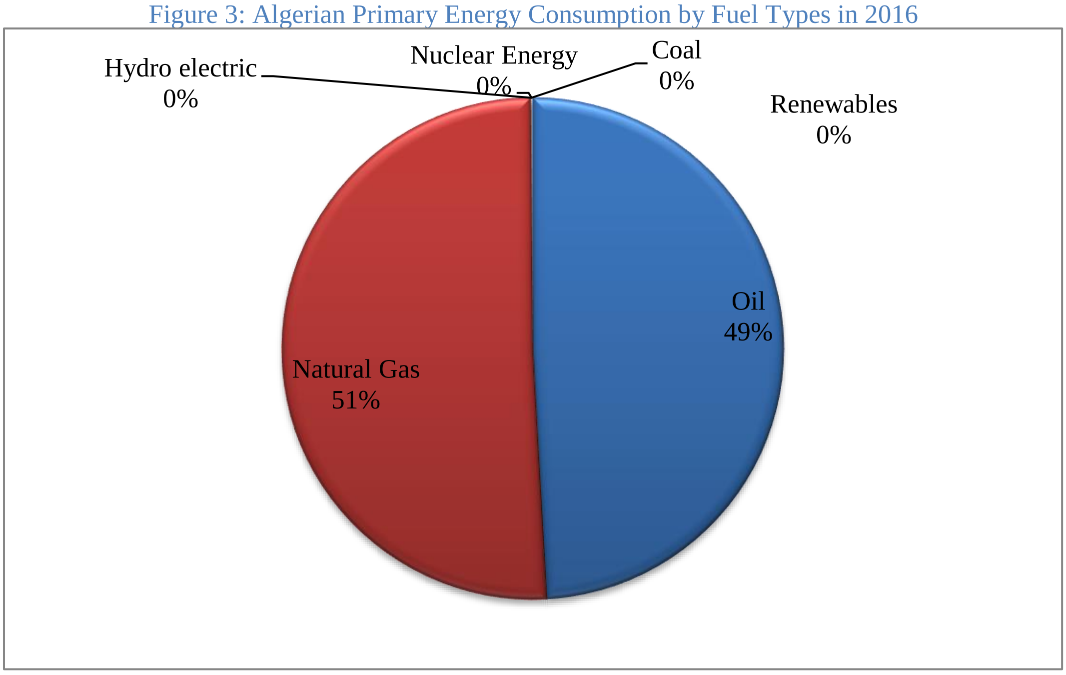
Beginning with Algeria, the country which is one of the net producers of natural gas, the country produced 92 billion cubic meters (bcm) and exported 54 bcm in 2016 (IEA, 2017). Oil and natural gas are the main supplier of the country. These two energy sources have also importance for the exports. In 2011, there was a transition from crude oil to natural gas in both production and exportation. Energy intensity and carbon dioxide emissions are continuously increasing in Algeria. Fossil fuels are the main reason of this situation. On the other hand, the country has one of the highest electricity access ratios, even though it's increasing population.

5.1 Analysis of Algeria

Algeria, formally known as the People's Democratic Republic of Algeria, is a country in the North of Africa. It shares borders with Morocco in the northwest, Western Sahara and Mauritania in the west, Mali and Niger in the south, Libya in the east, Tunisia in the northeast and has a long cost line along the Mediterranean Sea in the north. Algeria is the largest country in Africa covering an area of 2.381.741 square kilometers. Algeria has a population of almost 41 million people. Algiers is the capital of the country (CIA- the World Factbook, 2017).

Figure 2: Algeria in the world map
source: http://www.countryreports.org/

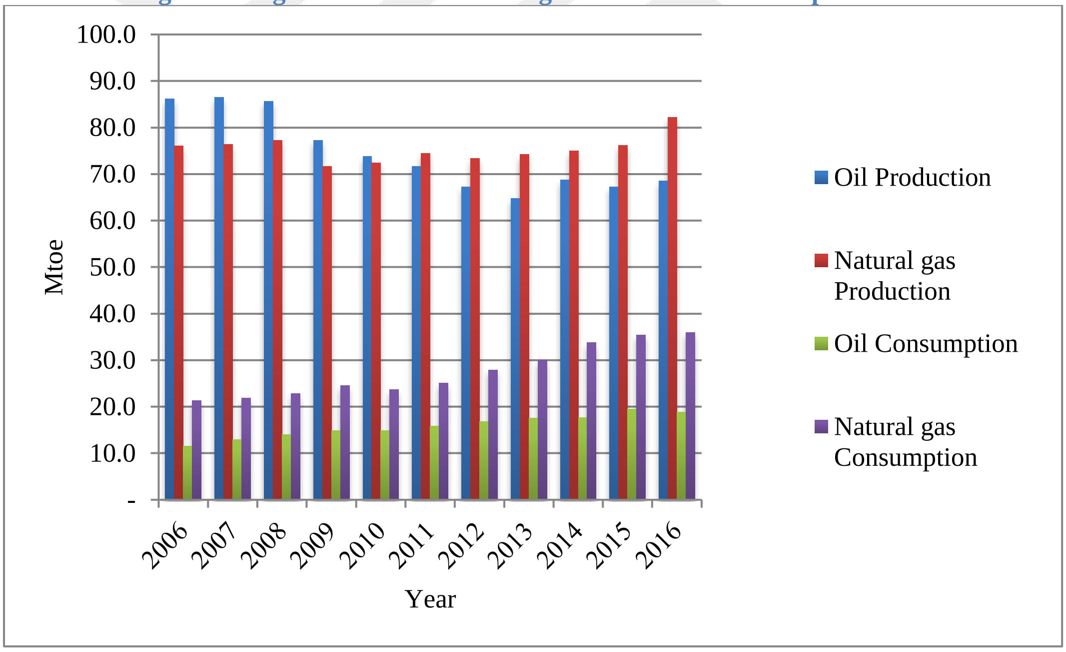
Figure 3: Algerian Primary Energy Consumption by Fuel Types in 2016



Source: AFREC, 2017

According to the African Energy Commission's (AFREC) Africa Energy Database 2017 Edition, natural gas and oil are the main energy sources in Algeria. In 2016, the total amount of energy consumption was 36.6 Mtoe. Coal, hydro electric and renewables have almost negligible effects overall. For instance, coal consumption was incredibly limited starting as early as 1965. According to BP data sets, the highest quantity consumed was 0.9 Mtoe, an amount that was reached only three times in 1985, 1986, and 2006. After the third highest consumed year, Algeria decreased coal consumption steadily to 0.1 Mtoe over the next nine years. Simultaneously, coal imports decreased from 0.72 to 0.14 Mtoe between 2006 and 2016 (International Energy Agency, 2018). Coal, hydro electric and renewables combined make up 1.4 TWh (0.12Mtoe). Due to the availability of oil and natural gas within proven reserves, the country's primary energy consumption revolves around these two rather than other energy sources.

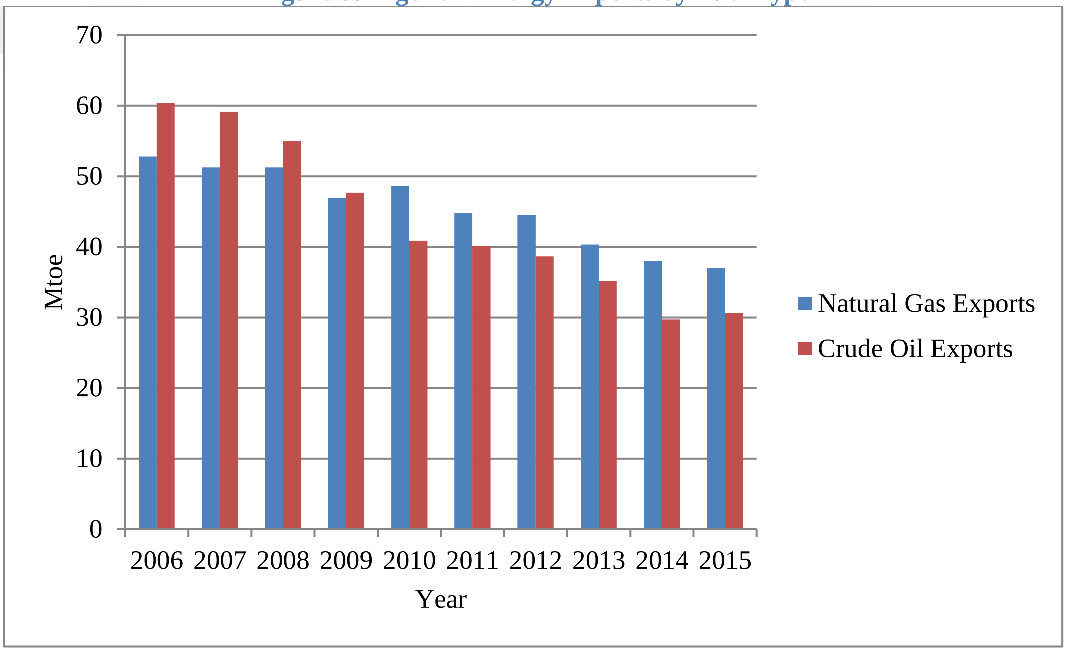
Figure 4: Algerian Oil and Natural gas Production/Consumption Data



Source: BP, 2017

Algeria had 1.5 billion tons of oil and 4.5 trillion cubic meters of natural gas in proven reserves at the end 2016. From 2006 to 2016, Algeria had shifted its energy focus from oil to natural gas, which was obviously reflected in production and consumption amounts (BP, 2017). In the first three years, there was approximately a 10% difference between oil and natural gas production. In 2009, the total production amount declined from 162.8 Mtoe to 148.8 Mtoe (77.2 oil and 71.6 natural gas), while total consumption increased almost 3 Mtoe. After that landmark year, overall natural gas production remained above its new threshold. The following year was the transition year; both produced and consumed energy decreased significantly, and natural gas production began surpassing oil production from 2011 to 2016. Furthermore, the amount of oil production decreased within a five year period starting from 2008, with 64.8 Mtoe as the lowest total production of oil in 2013. On the other hand, since 2006, both natural gas and oil consumption amounts increased constantly and independent from production amounts. At the commencement of this ten year period, total consumption was 32.9 Mtoe and increased one and half times to 54.9 Mtoe in 2016 (BP, 2017).

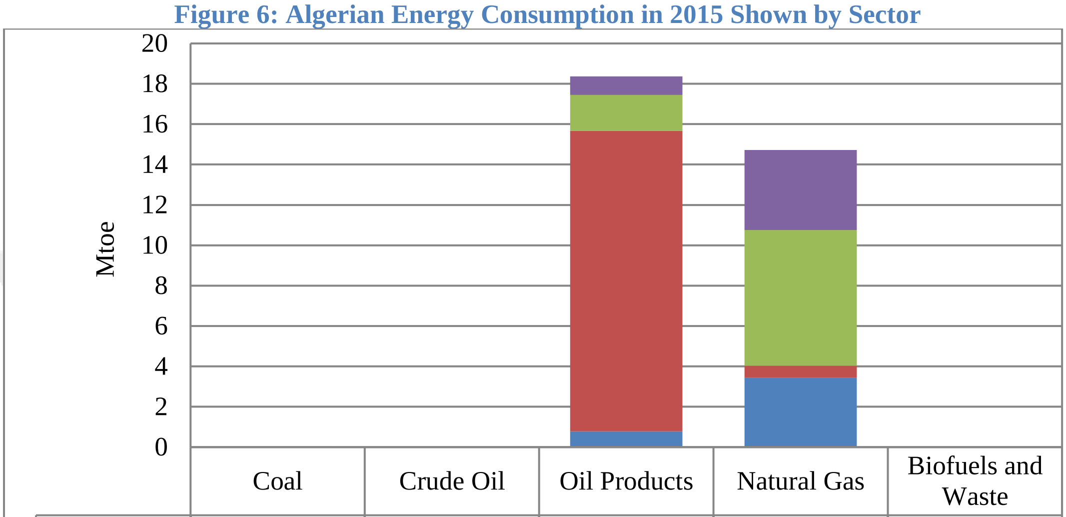
Figure 5: Algerian Energy Exports by Fuel Type



Source: IEA, 2018

In Africa, Algeria is third country in oil production and exports meanwhile first country in natural gas in the continent. In addition, Algeria is eight largest producer and fourth largest exporter of natural gas in the world. The amount of production was 92 bcm for production and 54 bcm for exportation in 2016. Similar to production and consumption amounts in between 2006 – 2016, the exports of natural gas and crude oil were also switched. In the first three years, crude oil was leading the energy exports in Algeria. Before the transition year, likewise the decrease in general production and consumption amounts, exports were declined and still crude oil was the main exported source in 2009. Since 2010, which was the transition year in energy for Algeria, natural gas became main exporting subject and still is keeping first place. Meanwhile, crude oil exports continuously declined up to 2014. On the other hand, Algeria imports so small amounts of crude oil and coal. Parallel with decrease of coal consumption between 2006 and 2016, coal imports also decreased from 0.72 Mtoe to 0.14 Mtoe in the period. Even though Algeria has great amount of oil reserves and production, imports so little amount of crude oil (IEA, 2018).

Figure 6: Algerian Energy Consumption in 2015 Shown by Sector

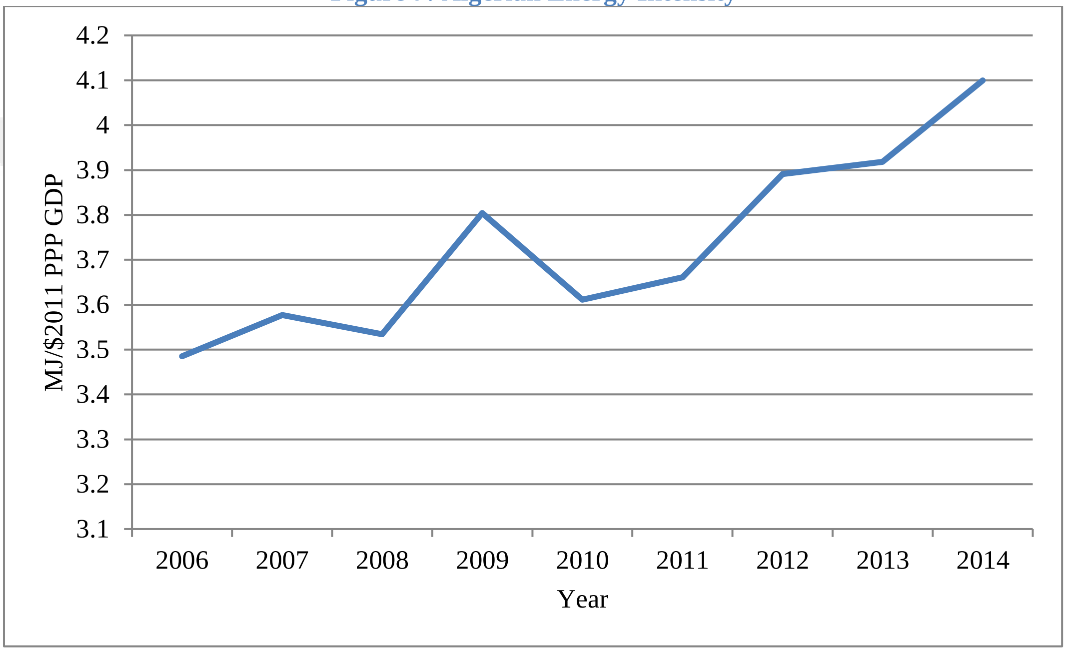


	Coal	Crude Oil	Oil Products	Natural Gas	Biofuels and Waste
Other			0.929	3.972	
Residential			1.763	6.718	0.002
Transport		0.006	14.892	0.606	
Industry	0.039		0.788	3.432	0.004

Source: IEA, 2018

IEA analyzes energy consumption, excluding electricity, within four categories in order to understand what sector is consuming what kind of energy and at what amount. In other words, it focuses research efforts on the diversification of energy sources by consuming sectors. According to IEA, industry, residential, transportation and other are the main categories for examining total consumption values. For Algeria in particular, agriculture/forestry, non-specified and non-energy use form the other category. Figure 6 highlights the Algerian dominant energy supplies' – natural gas, oil – dispersion by sector in 2015. Of the remaining three supplies, crude oil consumption, though minute, was the only one used in the transportation sector. Notably, this option had not been employed since 2006. According to IEA data sets, coal includes peat and oil shale as sources, which were preferred only by industry. Lastly, biofuels and waste consist charcoal, and minimally affect residential and industry. Shifting to the vertical axis, Figure 6 exhibits transportation as the leading sector with 15.5 Mtoe in total. The highest consumption volume in the sector was linked to oil products, which is common worldwide. Residential is the second most consuming sector among these four, with almost 9 Mtoe less than transportation. Finally, the industry sector used greatest diversification of energy sources, including coal and biofuels and waste, but wielded the least consumption amount. Between 2011 and 2015, Algerian energy consumption maintained a distribution among the sectors relatively similar to that shown in Figure 4 (IEA, 2018).

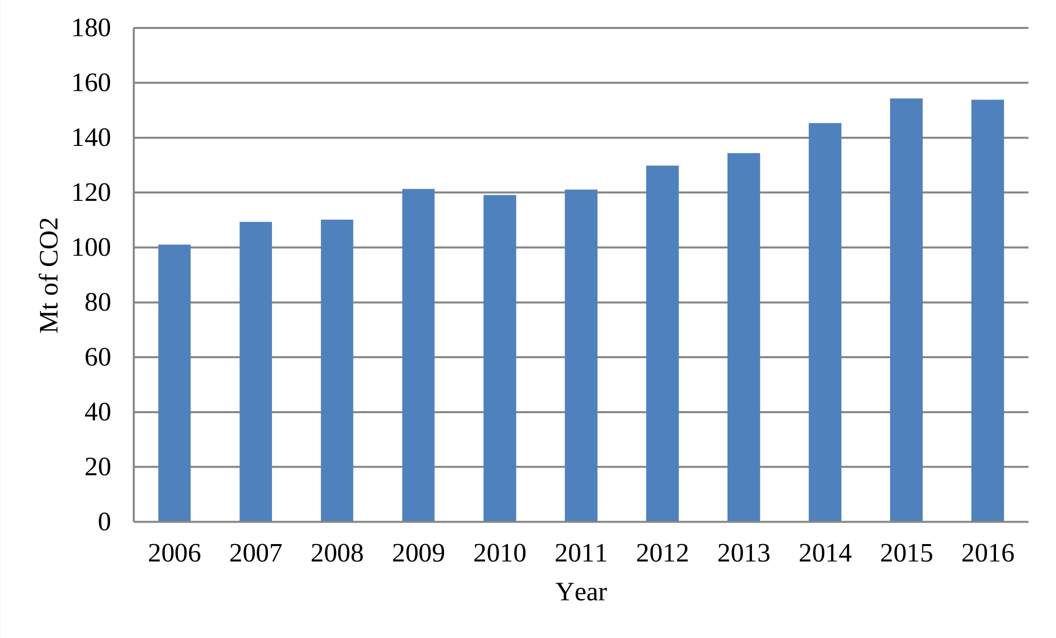
Figure 7: Algerian Energy Intensity



Source: World Bank, 2017

According to World Bank data sets, Algeria has 4.1 MJ, which equals 9.79 Mtoe, amount of energy intensity rate at the end of 2014. Like all other energy situations in the country, there were fluctuations in the energy intensity ratio, until the transition year. In 2010, general production and consumption amounts declined so that also the intensity rate decreased from 3.8 MJ to 3.6 MJ. After that year, there was a steady increase on Algerian energy intensity rates. Obviously, the correlation between primary energy production energy sources of the country and its reflection on intensity rates so clear in Algeria.

Figure 8: Algerian Territorial Emissions



Source: www.globalcarbonatlas.org , 2018

Algerian energy policy based on crude oil and natural gas reserves. Production, consumption and exportations of country, thoroughly demonstrate the effect of these two energy sources dominance. Furthermore, there is another issue related with this energy policy. As a result of high consumed fossil fuels, Algerian CO2 emission levels are increasing. In Figure 8, the change of emission amounts were exhibited from 2006 to 2016. It has started with 100 Mt of CO2 in 2006 and increased 153 Mt in 2016 which is one and half times of beginning in ten years period. Once it reached 120 Mt amount in 2009, only in the transition year it decreased below that line. After that year, the amount of CO2 emission kept steadily increased.

According to Electricity and Gas Regulation Commission of Algeria (CREG), there are four different electricity tariffs for household consumers. All tariffs cover production, transportation, distribution and marketing fees. The tariffs are;

- Triple Tariff – 51 M

This has three sections in a day, which are peak from 17.00 to 21.00 with 811.47 cDA per kilowatt hours (Algerian Dinar Coins), full-hours from 06.00 to 17.00 and

21.00 to 22.30 with 216.45 cDA/kWh and night from 22.30 to 06.00 with 120.50 cDA/kWh fee.

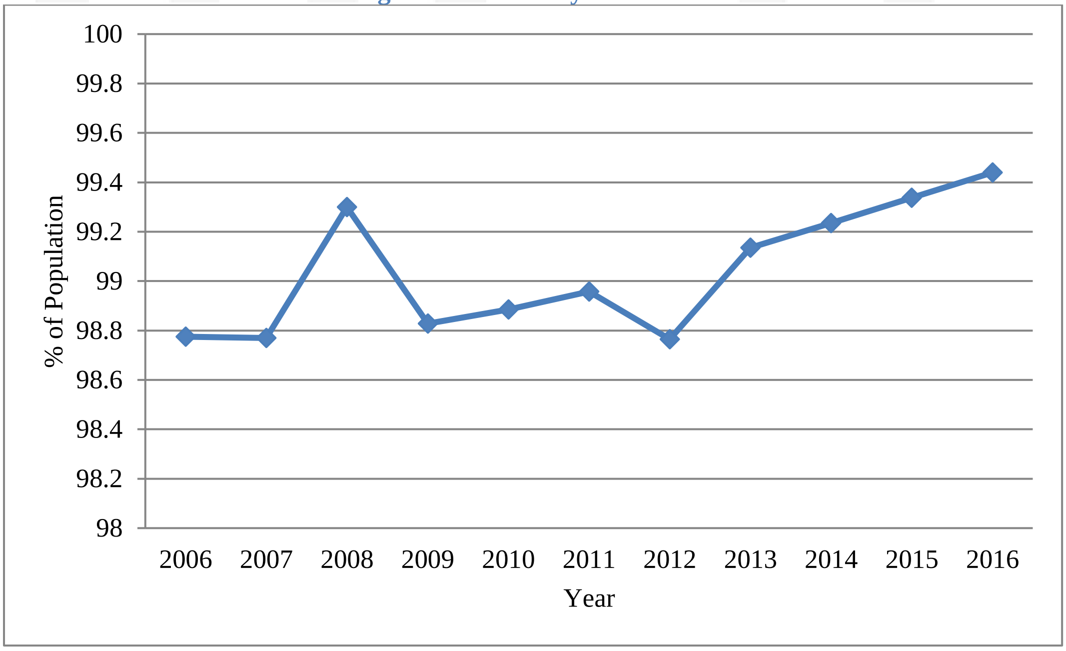
- Double Tariff – 52 M and 53M

52M is formed by peak and off-peak sections in a day. Peak is from 17.00 to 21.00 with 811.47 cDA/kWh fee and off-peak is from 21.00 to 17.00 178.07 cDA/kWh fee. 53M is composed by day and night parts. Day is from 06.00 to 22.30 with 486.98 cDA/kWh and night is from 22.30 to 06.00 with 120.50 cDA/kWh fee.

- Progressive Tariff – 54M

54M is the tariff which consumers get one in three months period and different than other tariffs, this has four slices which are defined the amounts of consumption in total. Slice 1 covers the usage up to 125 kWh with 177.87 cDA fee, Slice 2 covers consumption in between 125+ to 250 kWh with 417.89 cDA fee, Slice 3 covers the usage in between 250+ to 1000 kWh with 481.20 cDA fee and Slice 4 covers the consumption which is more than 1000 kWh with 547.96 cDA fee.

Figure 9: Electricity Access Ratio



Source: World Bank, 2017

In Figure 9, the accessibility of electricity demonstrated as a ratio between population and the ones who have access to electricity. Algeria has almost fully accessible electricity by its population, which leads the country among the top five countries in the Africa. At the end of 2016, 99.4% of the population has access to electricity. Algeria has a population which is approximately 41 million people. From 2006 to 2016, the ratio has not changed in big amounts. In the beginning it was 98.8% and small fluctuations between 0.2 – 0.4% happened, which has zero effect in general.

There is a one example of 54M tariff electricity bill from 25.03.2017, in appendix-A section. The total consumption was 340 kWh, which was calculated with slice 1, 2 and 3. The total cost was 1359.64 Algerian Dinar with taxes and fixed prices added. According to XE currency converter website, with the same date of bill, currency rates from DZD to USD the bill costs 11.51$.

5.2 Analysis of Egypt

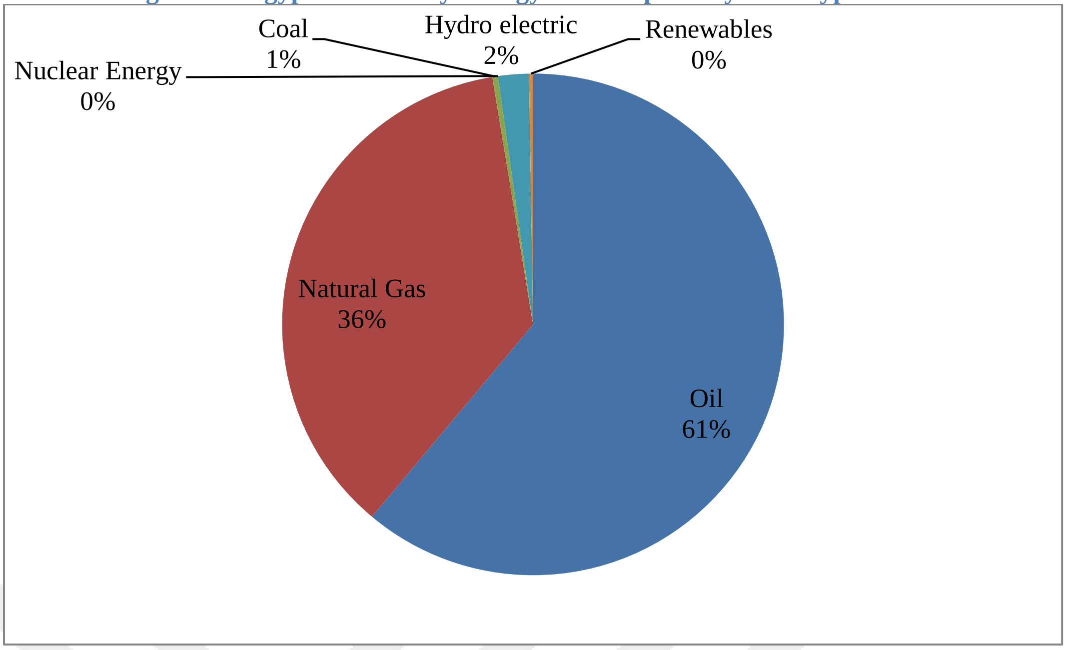
The country has both natural gas and crude oil reserves and centered these two fossil fuels as a main source. Similar to Algeria, Egypt switched crude oil to natural gas but they have started this transition earlier than Algeria. In the beginning of 2000, gradually decreased crude oil production and increased natural gas one. Until up to 2013, this policy continued also in exports. After that country re-planned its' usage of fossil fuels and decreased natural gas production progressively. Egypt also utilizes the hydro electricity, with not a big shares but something important for diversify of energy sources. Energy intensity levels of the country are in downtrend since 2006. Although, one of the top three most populous country in the continent, Egypt achieved to provide electricity access to its' all citizens since 2015.

Egypt, formally known as the Arab Republic of Egypt, is a country in the North East of Africa, as well as a small part of Asia, Sinai Peninsula. It shares borders with Libya in the West, Sudan in the South, the Gaza Strip and Israel in the northeast of country. Egypt has two coastlines; one is in the north of the country along the Mediterranean Sea and the other is in the east alongside the Red Sea. Furthermore, Gulf of Suez and Gulf of Aqaba are important geographical features of Egypt. The country covers an area of 1.001.450 square kilometers. Egypt has a population of almost 100 million people. Cairo is the capital of the country (CIA- the World Factbook, 2017).

Figure 10: Egypt in the world map
source: http://www.countryreports.org/

According to the AFREC's Africa Energy Database 2017 Edition, the fossil fuels are the main energy source in the country. Oil is the primary energy source responsible for more than half of the total consumption. In 2016, the total energy consumption amount was 59.1 Mtoe, with approximately 3% of total attributing to coal, hydro electric and renewables.

Figure 11: Egyptian Primary Energy Consumption by Fuel Types in 2016

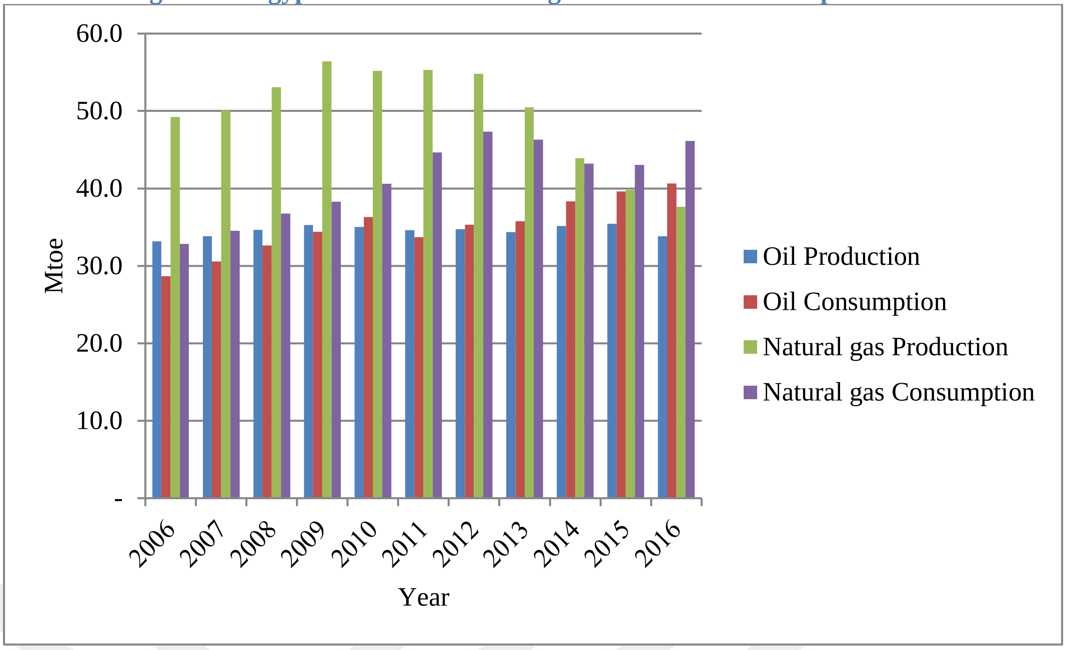


Source: AFREC, 2017

In the BP data sets, these three energy sources always had a limited effect on the country's total since 1965. Up until 2006, Egypt's coal consumption had fluctuated between 0.4 – 1.0 Mtoe. Since then, the amount of consumption decreased steadily from 0.9 Mtoe to 0.4 Mtoe over the next ten years. In addition, the country had 2.8 GW hydro electric installed capacities. Meanwhile, at the end of 2016, the country had 1.8 trillion cubic meters of natural gas and 0.5 billion tonnes of crude oil reserves. The reason behind this long period of consuming trend in Egypt is the proven reserves of crude oil and natural gas (BP, 2017).

Egypt had taken advantage of the proven reserves of fossil fuels in primary energy production and consumption. Until the year 2000, crude oil was the main energy source that Egypt utilized. Natural gas also had a remarkable effect, but still less than that of crude oil. Beginning in 2000, Egypt reduced the crude oil supplies and increased those of natural gas. In 2005, this shift was complete and from that point on, natural gas remained the primary source of supply and consumption in the country. Figure 12 depicts an increase in natural gas production culminating in a peek amount of 56.4 Mtoe in 2009, marking the highest production level in Egypt ever.

Figure 12: Egyptian Oil and Natural gas Production/Consumption Data

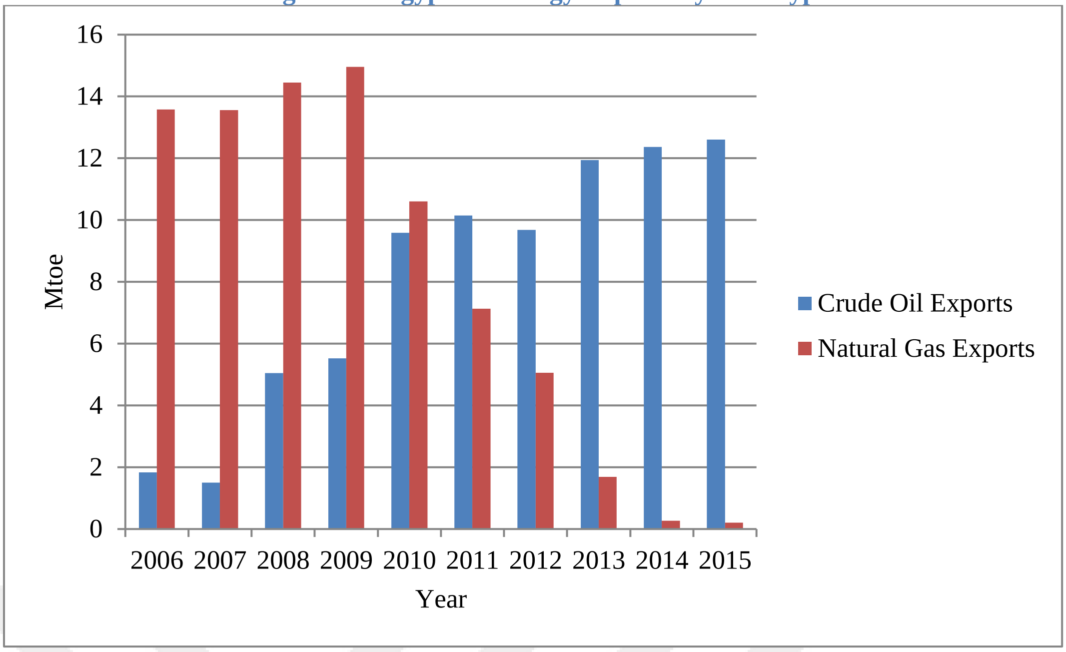


Source: BP, 2017

In the following three years Egypt tried to sustain this production rate, averaging around 55 Mtoe per year. After 2012, natural gas production decreased continuously to 37.6 Mtoe in 2016. On the other hand, Egypt successfully kept oil production in balance throughout the decade in question. In 2006, production levels only reached 33.2 Mtoe, the lowest historical amount. After ten years of insignificant fluctuations, the highest value was 35.4 Mtoe in 2015. Simultaneously with the boost in production, the natural gas consumption was also steadily increased until up to 2013 (BP, 2017).

Crude oil and natural gas are two main energy sources for the country. Similarly, both are forming the main supply and consumption in Egypt. Additionally, these two energy sources are the main exporting assets of it. From 2006 to 2015, Egypt prioritized one of the each for three to four years period. In the first four years, natural gas was the main exported energy source from Egypt. At the same period, the country’s natural gas production and consumption amounts was more than crude oil. Natural gas export amounts began approximately 13.5 Mtoe in 2006 and reached the 15 Mtoe, which was the highest in total, at the end of four year period. Meanwhile, oil exports were so low, around 1.8 Mtoe, but increased to 5.5 Mtoe in 2009.

Figure 13: Egyptian Energy Exports by Fuel Type

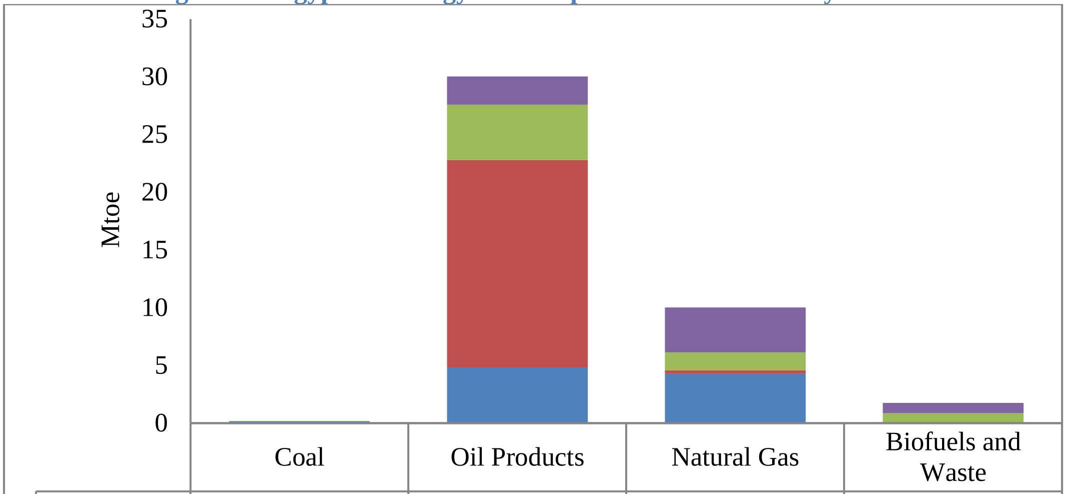


Source: IEA, 2018

The following three years period was the transition years for the country. While, crude oil exports continued to increase between 2010 and 2012, natural gas exports decreased steadily. In this three years period, Egypt had shifted natural gas exports with crude oil exports. The last three years period, which was from 2013 to 2015, country's natural gas exports decreased almost to zero. On the other hand, crude oil increased continuously from 11 Mtoe in 2013 to 12.5 Mtoe in 2015. Egypt decreased the exports of natural gas in order to utilize it in the country. Furthermore, the country had decreased its own natural gas production, in the meantime, the consumption amounts steadily increased (IEA, 2018).

According to IEA's sectoral analysis of energy consumption, for Egypt in particular, the other category consists of agriculture/forestry, non-energy use and non-specified sub-sections. The transportation sector has the highest amount among the four, with 18.2 Mtoe. Oil products are the main supplier of this sector. The remaining three sectors exhibit significantly smaller amounts, similar in quantity, with less than notable differences among them. Industry is the second highest sector with a total amount around 9 Mtoe, half the size of the leading sector. Residential and other both have total consumption rates of approximately 7 Mtoe. Although residential is the lowest sector among the four, it has the most diversified dispersion of energy sources.

Figure 14: Egyptian Energy Consumption in 2015 Shown by Sector



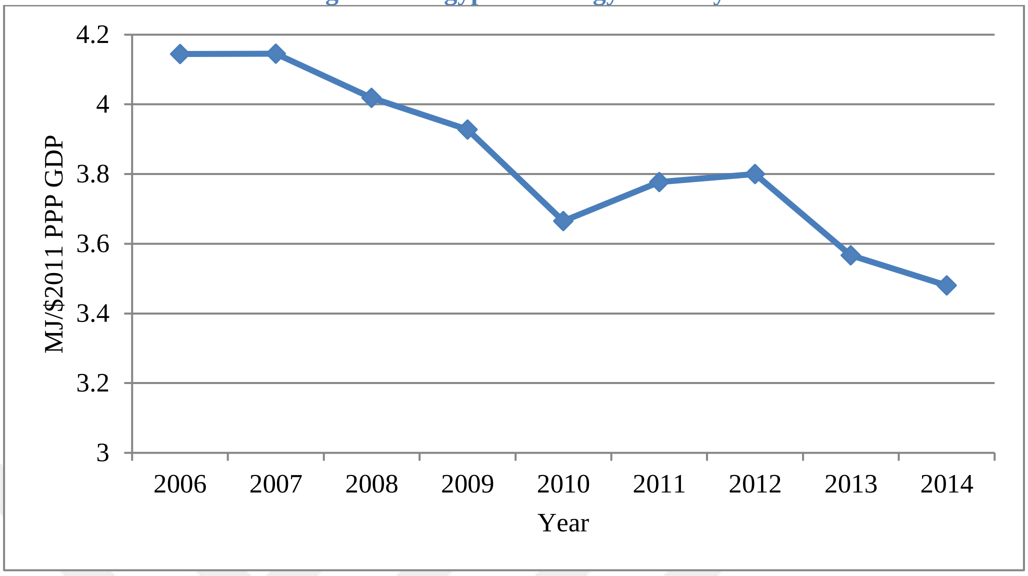
	Coal	Oil Products	Natural Gas	Biofuels and Waste
Other		2.446	3.906	0.893
Residential	0.002	4.791	1.541	0.857
Transport		17.967	0.318	
Industry	0.179	4.824	4.266	

Source: IEA, 2018

Oil products yield the highest volume within the residential sector, whilst coal has the lowest impact on the sector's consumption. The industry and other sectors each have three contributing portions, the only distinction is that industry prefers coal and the other utilizes biofuels and waste. Despite its high volume, transportation has very limited diversification in energy sources – only oil products and natural gas. In addition, oil products have almost 98% of the total in this sector. The dominance of oil and natural gas is related to the proven reserves and the country's main energy policy. Between 2011 and 2015, Egyptian energy consumption maintained a distribution among the sectors relatively similar to that shown in Figure 12 (IEA, 2018).

According to WB data sets, in 2014, Egypt had approximately 3.5 MJ (MJ/$2011 PPP GDP), which equals 7.2 Mtoe, amount of energy intensity rate. Between 2006 and 2014, country's energy intensity level had different situations. In a three years period since 2007, the amount had decreased from 4.2 MJ to 3.7 MJ. On the production side, Egypt continuously increased its overall production amount and reached 70.6 Mtoe from oil and natural gas, at the end of 2010. The following two years, with the boost in natural gas production, which 47.3 Mtoe was the highest production amount in 2012, there was a small increase also in energy intensity level. Since 2012, the last two years in the figure 15, the overall decreased continued and reached the lowest amount which was 3.5 MJ. 2014 was the year that Egypt also decreased its natural gas production amounts and continued to decrease in 2015.

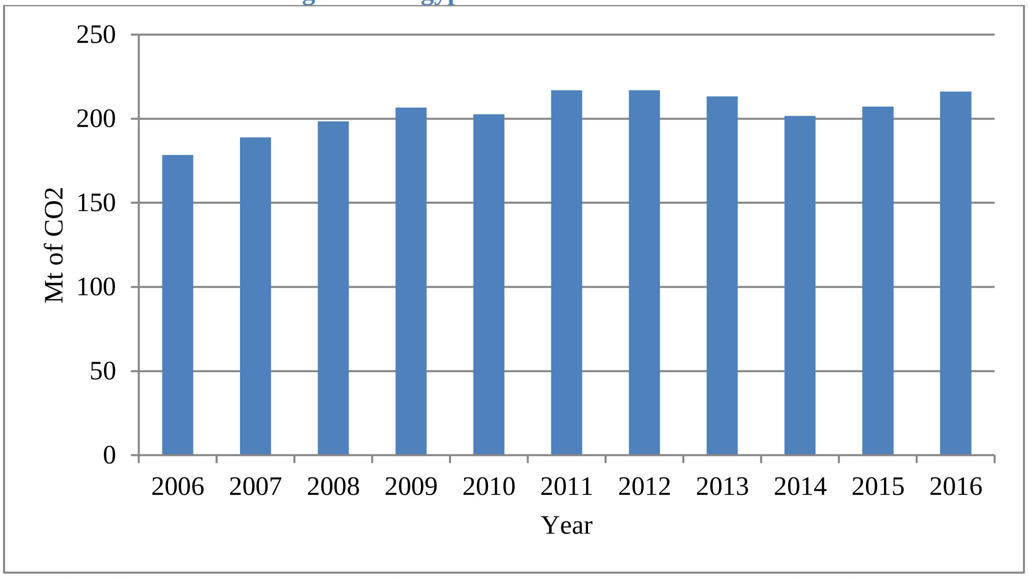
Figure 15: Egyptian Energy Intensity



Source: World Bank, 2017

In the Figure 16, there was a slightly fluctuations on Egypt's CO2 emission levels. In 2006 it was started with 178 MTCO2 emissions and reached 216 MTCO2 at the end of 2016. Obviously, country's main energy policy, dominance of crude oil and natural gas, was the exact reason of that increase. There was two negligible decrease periods in the eleven years; first one was in 2010 and second one was in 2014. In the beginning, between 2006 and 2009, the levels of CO2 emissions were increased continuously from 178 to 206 MTCO2. The premier decreased happened in the country, on the other hand there was no decline in the production and consumption amounts. The following three years, that was also the natural gas boost phase in the country. That boost led a great increase also in emission levels. In 2011, it was measured that the amount 216 MTCO2, which was the highest in overall and repeated in 2012. After that high consumed three years, the second decreased happened which was declined approximately 12 MTCO2 amount and measured as 201 MTCO2 in 2014. Natural gas decrease was the reason for that decrease in the year. The last two years the emission levels kept steadily increased and reached again the highest amount one more time since 2012, in 2016 (WB, 2017).

Figure 16: Egyptian Territorial Emissions



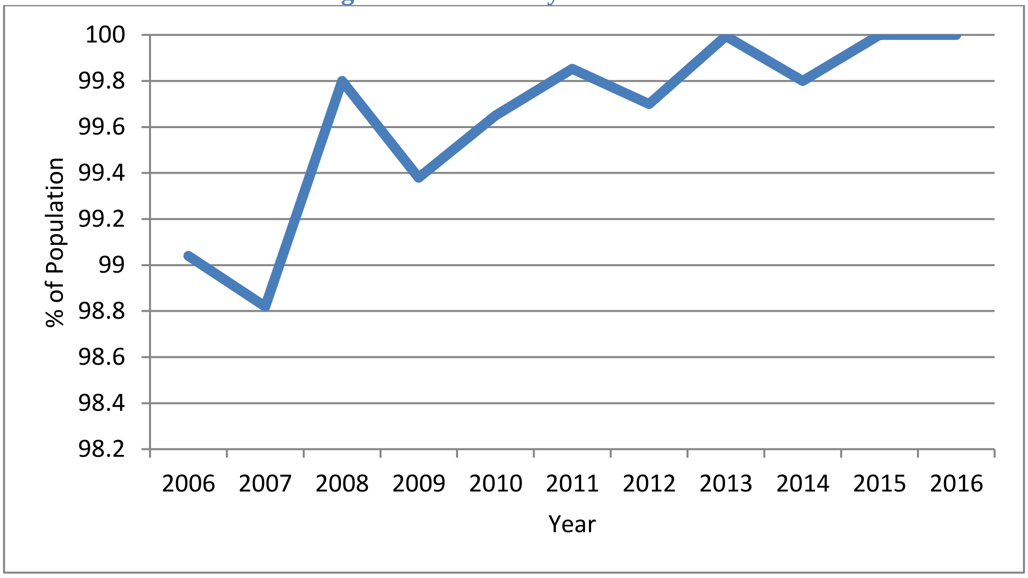
Source: www.globalcarbonatlas.org , 2018

According to Egyptian Electricity Holding Company (EEHC), that is the governmental organization responsible for all power plants, transmissions and distributions, there are seven different pricing slices for electricity tariffs. These slices based on the monthly consumptions. For residential usage;

- 0 to 50 kWh/monthly – 7.5 Piasters/kWh
- 51 to 100 kWh/monthly – 14.5 Piasters/kWh
- 101 to 200 kWh/monthly – 16 Piasters/kWh
- 201 to 350 kWh/monthly – 30.5 Piasters/kWh
- 351 to 650 kWh/monthly – 40.5 Piasters/kWh
- 651 to 1000 kWh/monthly – 71 Piasters/kWh
- More than 1000 kWh/monthly – 84 Piasters/kWh

The Egyptian Pound (EGP) is the currency of country and coins are called as piasters. In the website of EEHC, there is a tool for calculating the electricity consumption and find the price without taxes added. To be consistent, the similar consumption amount of bill from Algeria, was calculated in the website and currency rate checked on the same source – XE-, 340 kWh consumption equaled 74.69 EGP and which was 4.13$.

Figure 17: Electricity Access Ratio



Source: World Bank, 2017

Egypt is one of the most populated countries in the continent of Africa, and the country reached 100% electricity accessibility rates at the end of 2015. Egypt had a population of approximately 100 million people at the end of 2017. Figure 17, illustrates sizable fluctuations but in actuality, the amounts are much lower when measured in percentages. For instance, in the beginning, from 2006 to 2007, there was a decrease of almost 0.2%, when the population grew from 77.7 to 79 million. There was a substantial increase from 2007 to 2008, during which Egypt's population reached almost 81 million people. The following year faced a decrease of around 0.4% accessibility per person, with the total population measuring 82 million people. Egypt initially reached 100% electricity accessibility rates at the end of 2015 and then sustained it through 2016. Despite the significant population of the country Egypt became successful in providing access to all of its citizens, which is a challenging feat for any large nation (WB, 2017).

5.3 Analysis of Nigeria

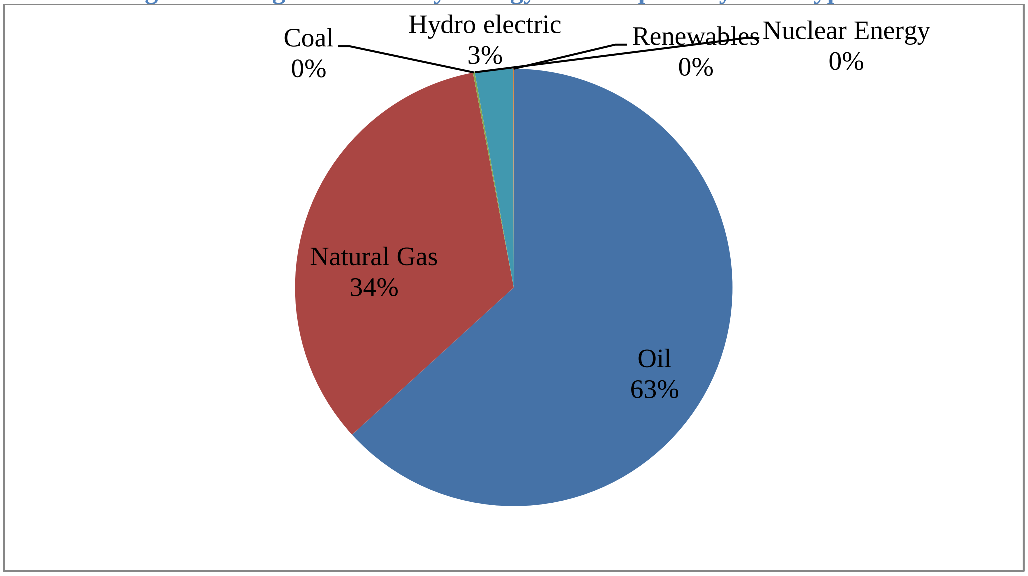
Similar to most of the African countries, Nigeria also utilizes fossil fuels as a primary energy sources. According to IEA, the country is one of the net exporters of crude oil in the world. Nigeria exported 104 Mt of crude oil in 2016. The total consumption of country is not more than 20 Mtoe and crude oil is the major energy source. The energy intensity levels of country are decreasing since 2006 but it is still one of the highest in the continent. Nigeria is the most populous country in the Africa and accessibility of electricity is above the average level in the continent but not sufficient for its' all citizens.

Figure 18: Nigeria in the world map source: http://www.countryreports.org/

Nigeria, formally known as The Federal Republic of Nigeria, is a country in the West of Africa. It shares borders with Benin in the West, Niger and Chad in the North and Cameroon in the East. In the south, the country has a long cost line, which the area named as Gulf of Guinea, along the Atlantic Ocean. Nigeria covers an area of 923.768 square kilometers. The country has a population approximately 190 million people, which Nigeria is the most populous in the Africa and among the top ten countries in the world. Abuja is the capital of the country (CIA- the World Factbook, 2017).

According to the AFREC's Africa Energy Database 2017 Edition, the fossil fuels are the main energy sources in the country. Oil is the premier energy source with more than half of the total and natural gas is the supporter of it. In 2016, the total energy consumption amount was 18.6 Mtoe in Nigeria. Approximately 3% share of total formed by coal, hydro electric and renewables. According to Key Africa Energy Statistics 2017, 5.7 GWh electricity produced by hydro power plants and 3.9 Mtoe charcoal was produced in Nigeria. 5.3 TCM NG, 37.1 billion barrels crude oil reserves.

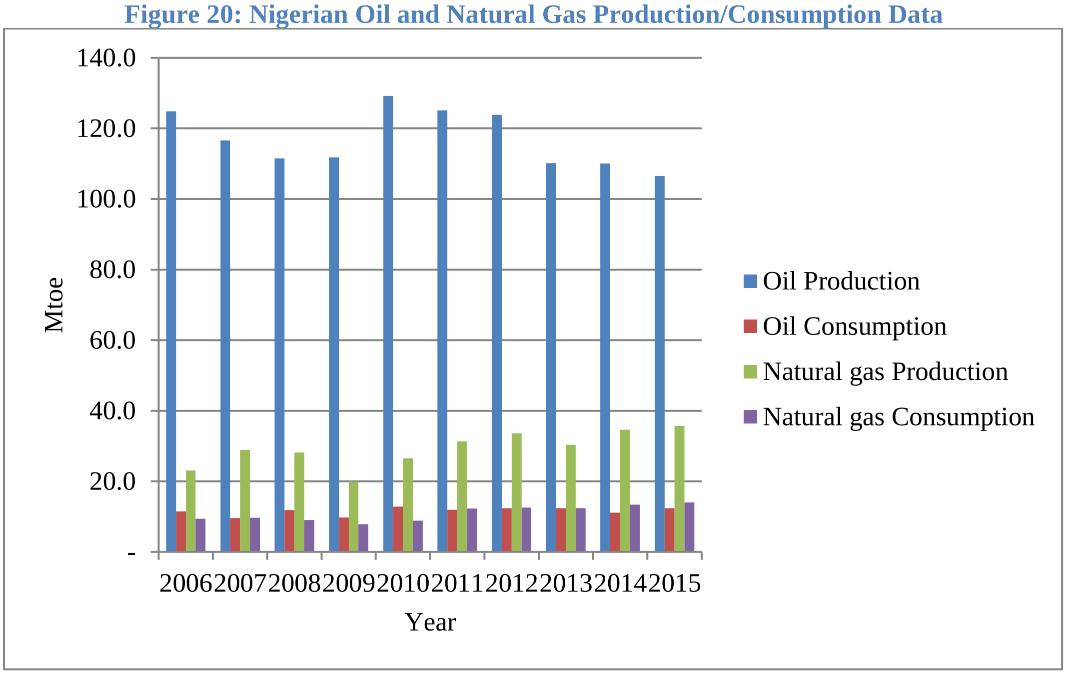
Figure 19: Nigerian Primary Energy Consumption by Fuel Types in 2016



Source: AFREC, 2017

Nigeria has taken advantage of the proven reserves of fossil fuels in primary energy production and consumption. Especially, crude oil is the main source in the country. According to AFREC, Nigeria is the main producer and exporter country of crude oil in the continent, meanwhile one of the top ten net exporter countries in the world. In the figure 20, it highlights undoubtedly the dominance of crude oil production. From 2006 to 2008, the overall production amount had decreased from 124.9 Mtoe to 111.5 Mtoe.

Figure 20: Nigerian Oil and Natural Gas Production/Consumption Data



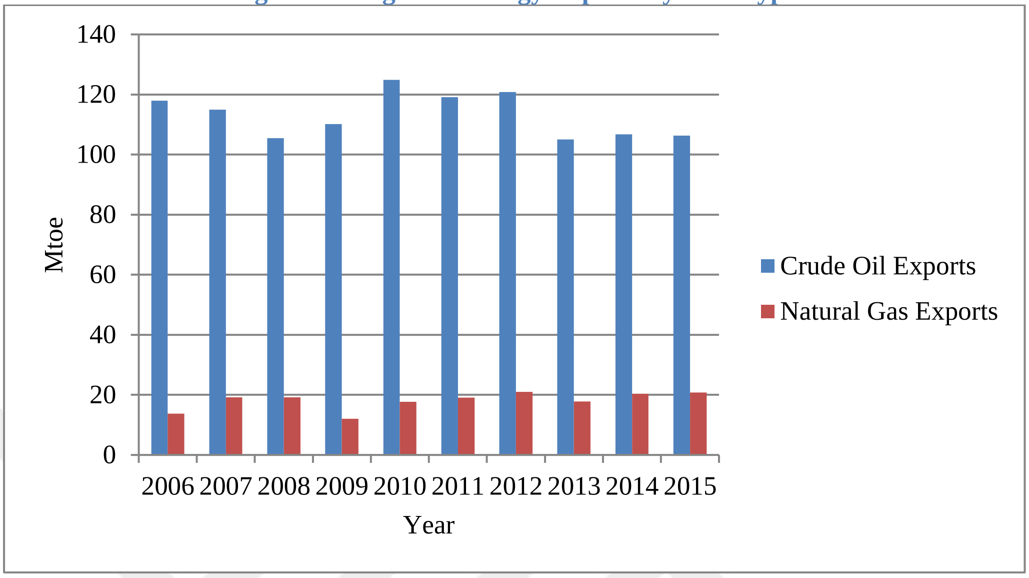
Source: BP, 2017

The following your country kept the production amount almost stable and started to boost it in 2010 and tried to keep the amount over 120 Mtoe until to 2013. In 2010, the production of crude oil reached the highest amount in general with 129.2 Mtoe. In that three years, on condition to keeping production amount over 120 Mtoe, year by year Nigeria decrease the crude oil production. The following year (2013), a sharp decreased happened, which was declined to more or less similar amount before the boost in 2010. In 2014, the country attempted to keep in balance the production amount with the previous year and continued to decrease overall production in 2015. As it can understandable by the figure and numbers, Nigeria's crude oil policy consisted particular periods for decrease and boost in order to protect the balance and using sources efficiently. Unlike the crude oil dominance, natural gas small effect on Nigerian energy industry. Similar to beginning of crude oil, natural gas production amounts were also increased in between 2006 and 2008. The year 2009 and 2013, were the transition year for the country. All production and consumption amounts decreased in that year. In 2009, the lowest amount of natural gas production measured in Nigeria, 19.9 Mtoe. After that one year break, natural gas production continued to increase from 26.6 Mtoe in 2010 to 33.7 Mtoe in 2012. The following transition year, natural gas production decreased to 30.4 Mtoe, which was the lowest after that boost period. The overall production amount continued to increase in the last two years and reached 35.7 which was the highest in total in 2015. The country kept in balance the crude oil and natural gas consumption in the ten years period with small fluctuations. Between 2006 and 2010, crude oil consumption was more than natural gas and only in 2007 these two energy sources were almost similar amounts. After 2010, the second five year of the overall, natural gas consumption increased and surpassed crude oil. Only in 2013, the total consumptions amounts were more or less similar of the crude oil and natural gas (IEA, 2018).

Crude oil and natural gas are two main energy sources for the country. Similarly, both are forming the main supply and consumption, with oil dominance, in Nigeria. Additionally, these two energy sources are the main exporting assets of it. From 2006 to 2015, similar policy, which was applied on production and consumption sectors of crude oil, preferred by the country for exports also. In the first three years, Nigeria decreased the crude oil exports and increased in small amount of natural gas. In the beginning, the crude oil export amounts were 117.9

Mtoe and natural gas was 13.7 Mtoe. At the end of that three year period in 2008, crude oil amounts were decreased to 105.5 and natural gas amounts were increased to 19.2 Mtoe.

Figure 21: Nigerian Energy Exports by Fuel Type

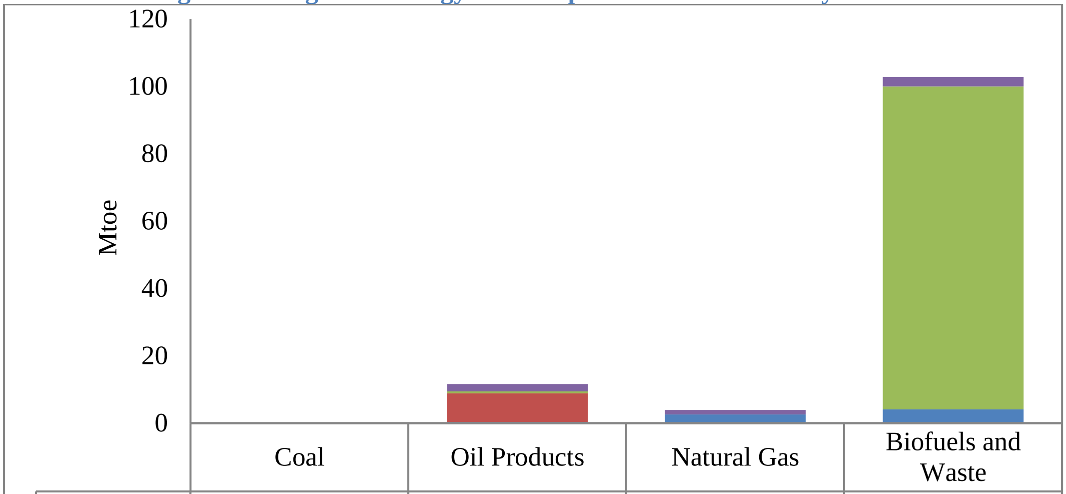


Source: IEA, 2018

In the premier transition year of the country, crude oil exports increased but natural gas exports decreased. In that year, natural gas exports amount was the lowest in overall which was 12 Mtoe. The following three years period, Nigeria steadily increased the crude oil exports and in 2010, reached the highest amount in total with 124.9 Mtoe. Furthermore, natural gas exports increased also in that period. In the second transition year, both natural gas and crude oil exports of the country decreased and 105 Mtoe was the lowest value for crude oil exports. In the last two years, the country kept increase in both energy sources and crude oil was measured 106.3 Mtoe at the end of 2015. In that year, the highest amount of natural gas exports was measured for the country which was 20.8 Mtoe (IEA, 2018).

According to IEA's sectoral analyzes of energy consumption, for Nigeria in particular, other consist of commercial and public services, agriculture/forestry, non-energy use and non-specified sub categories. Biofuels and waste source was the most preferred one around the four (coal, oil products, natural gas and biofuels). Residential sector was forming the majority around the others. Firewood and charcoal is in the list of biofuels and waste. Nigeria was the main producer of firewood and one of the top three countries in charcoal production in the continent.

Figure 22: Nigerian Energy Consumption in 2015 Shown by Sector



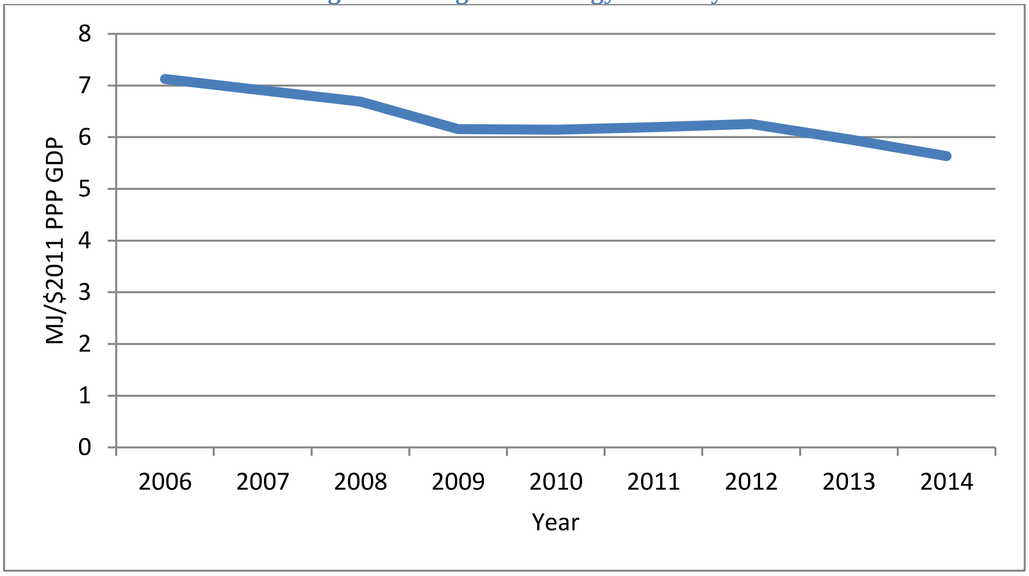
	Coal	Oil Products	Natural Gas	Biofuels and Waste
Other		2.189	1.382	2.771
Residential		0.541		95.884
Transport		8.428		
Industry	0.029	0.434	2.558	4.153

Source: IEA, 2018

In general, West Africa forms 27% of both charcoal and firewood production in the Africa. Industry and other sectors were consumed around 6.7 Mtoe from biofuels and waste. In the remaining three sources, oil products were in the second among the four others and transportation sector was the main consumer of the source with 8.4 Mtoe in total. At the same time, Oil products were the most diversified energy source in the country. These all four sectors consumed particular amount of it. The fallowing source was natural gas, which the consumption formed by other and industry sectors and 3.8 Mtoe in total. Coal was the minimal preferred source and only by industry sector. The most diversified sector was industry sector in Nigeria. All four energy sources had an effect in the sector. The other sector was the second most diversified with consuming three of the four energy sources except coal. The least diversified one was transportation sector which was only formed by oil products. Between 2011 and 2015, Nigerian energy consumption maintained a distribution among the sectors relatively similar to that shown in Figure 20 (IEA, 2018).

According to WB data sets, in 2014, Nigeria had approximately 5.6 MJ (MJ/$2011 PPP GDP), which equals 13.3 Mtoe, amount of energy intensity rate. Between 2006 and 2014, country’s energy intensity level had declines and stabilities. In a four years period since 2006, the amount had decreased from 7.1 MJ to 6.1 MJ.

Figure 23: Nigerian Energy Intensity

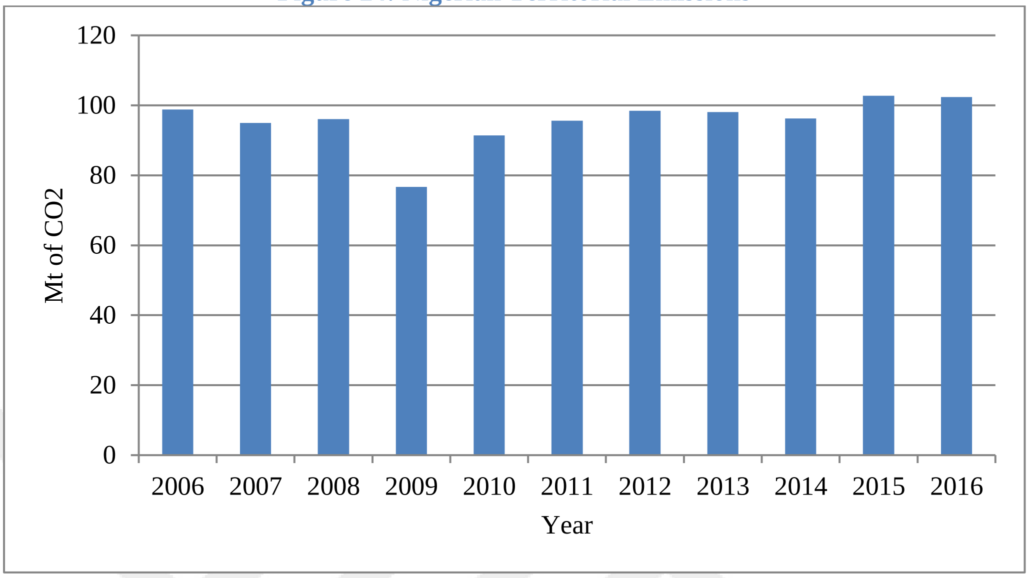


Source: World Bank, 2017

On the production side, the decrease in oil and increase in natural gas and the exports policy of the country reflected also the energy intensity in Nigeria in a balanced way. By slow degrees the high intensity level decreased 1 MJ in four years period. In the second four year period, between 2009 and 2012, Nigeria attempted to keep the intensity level more or less similar on 6.1 MJ and only 0.1 MJ increased happened at the end of 2012 which was measured 6.2 MJ. In the last two years, the country reserved the decrease and reached the 5.6 MJ which was the lowest amount in the overall period.

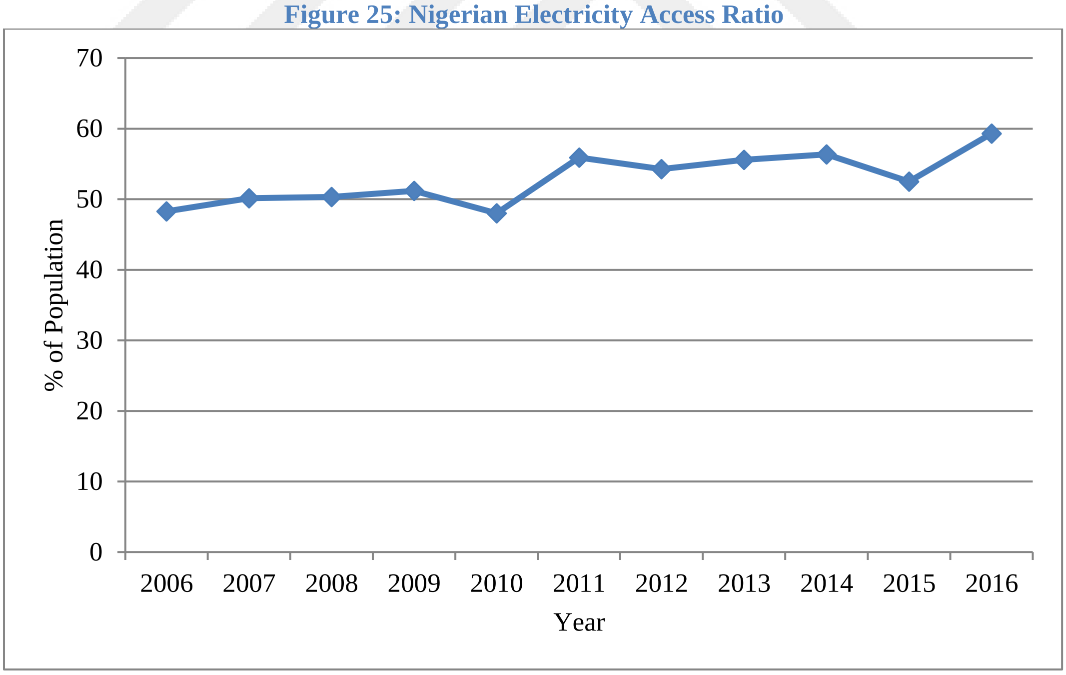
In the Figure 24, there was a slightly fluctuations on Nigeria's CO2 emission levels. In 2006 it was started with 98 MTCO2 emissions and reached 102 MTCO2 at the end of 2016. Obviously, country's main energy policy, dominance of crude oil and supports by natural gas, was the exact reason of that increase. The decrease of crude oil production in between 2006 and 2008, it impacted a decrease also in CO2 emissions in the country. In the premier transition year, Nigeria created the lowest emission amount with 76 MTCO2 in overall. The effect of general consumption and production decline was so notable. Similar to increase years in total, the emission levels were also increased and reached one of the highest values in 2012 with 98 MTCO2. In the second transition year, only the production amounts of the country decreased and consumption amounts kept the similarity with the previous year and as a result of that there was no change or decrease in CO2 emissions in the country. Surprisingly a small decline happened in 2014 which was 2 MTCO2 and total emission decreased to 96 MTCO2. The following years, Nigerian emission levels increased similar to its production and consumption levels and reached to 102 MTCO2.

Figure 24: Nigerian Territorial Emissions



Source: www.globalcarbonatlas.org , 2018

Figure 25: Nigerian Electricity Access Ratio



Source: World Bank, 2017

Nigeria is the most populated country in the continent; approximately the country has a population with 190 million people at the end of 2017. Nevertheless, with a great amount of reserves and production amounts, crude oil in particular, the country has a big issue to provide electricity access to all citizens. Between 2006 and

2016, country had increased the electricity accessibility rate from 48% to 59% even though the population also increased. In 2006, Nigeria’s population was 142 million and reached to 185 million at the end of 2016. More or less 68 million people had access on electricity in 2006 and the amount almost doubled in 2016, approximately 109 million (WB, 2018).

According to Nigerian Electricity Regulatory Commission, there are eleven electricity distribution companies (DisCos) operating in the country and each has specific tariff class. Residential, commercial, industrial customers, government agencies, religious bodies and street lights are the main classes which each have three sub-classes except street lights one and residential has four sub-classes. There is the example of tariff list table, sample electricity bill and DisCos map of Nigeria in the appendix-A section. The sample bill from 14.12.2017, tariff class R2, which covers the customers with consumptions above 50 kWh per month. Total consumption was 63.9 kWh and cost was N2.000.000 – Nigerian Naira (NGN) is the currency of country – Considering the currency rates from XE, that was equal to 5.5$.

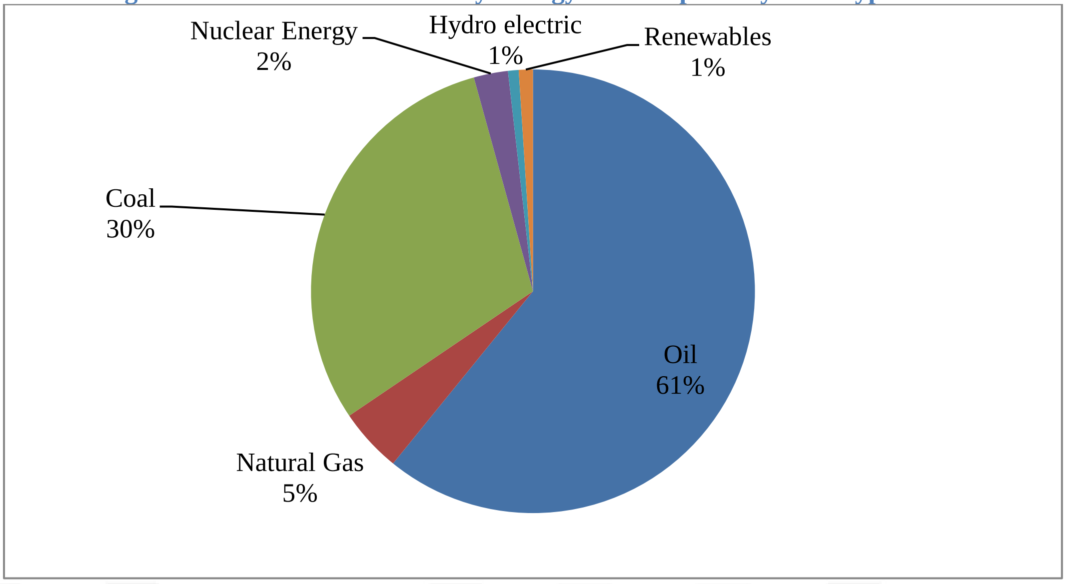
5.4 Analysis of South Africa

South Africa is the only country that utilizes nuclear power plants in the Africa and they have two reactors. The country is one of the largest coal producer and net exporter country in the world. South Africa was responsible from 3.5% of coal production and exported 76 Mt in 2016. Despite the majority of fossil fuels, the country has most diversified primary energy consumption in the continent. The country has one of the highest emission levels, in average it is more than 470 Mt. Eskom is the main electricity supplier in the country and in their data sets, approximately %15 of population does not have access to electricity due to geological reasons and lack of infrastructure.

Figure 26: South Africa in the world map source: http://www.countryreports.org/

South Africa is a country at the southern tip the continent of Africa. There are eleven official names of the country from of its eleven official languages. South Africa is the second country in the world with that number of official names and languages. Republic of South Africa is the most used one. These languages includes; English, Afrikaans, Tswana, Sotho, Northern Sotho, Venda, Tsonga, Zulu, Xhosa, Ndebele and Swazi. It shares borders with Namibia, Botswana, Zimbabwe and Mozambique in the north of country, Lesotho and Swaziland are the countries which entirely surrounded by South Africa. The country has a long cost line along the Atlantic Ocean in the south of country. The area has also Cape Agulhas. South Africa has three capitals, one is Pretoria known as administrative capital, Cape Town identified as legislative capital and Bloemfontein is the judicial capital of the country. South Africa has a population around 56 million people (CIA, 2017).

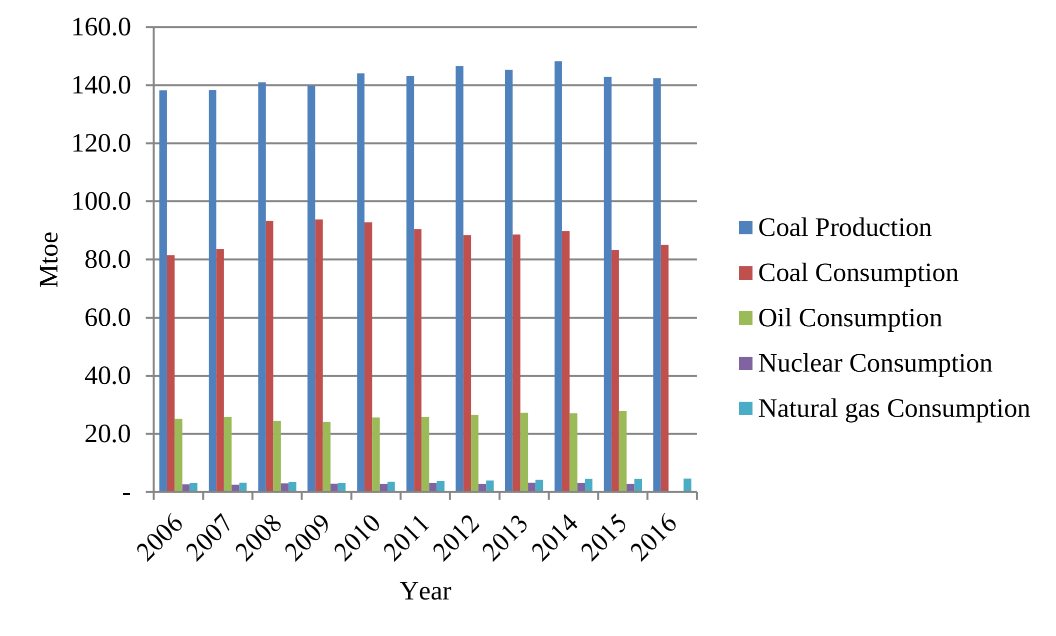
Figure 27: South African Primary Energy Consumption by Fuel Types in 2016



Source: AFREC, 2017

According to the AFREC's Africa Energy Database 2017 Edition, South Africa has diversified primary energy consumption. The main energy source is oil, more than half of the total. The rest are formed by five different energy sources, which are coal, with the highest share in the group, natural gas, renewables, hydro electric and the nuclear energy. South Africa is the only country in the Africa that currently producing electricity from nuclear. According to World Nuclear Association (WNA), the country has two operable nuclear reactors. The total energy consumption was 42.7 Mtoe in 2016. Coal, natural gas, renewables, hydro and nuclear covers 16.7 Mtoe. According to BP (2017), South Africa is the leading country in the Africa with its coal reserves, which are in total 9893 Mtoe anthracite and bituminous coal. The country is one of the top ten main producers and exporters in the world (IEA, 2017). In the data sets, hydro electricity started to be utilize in 1971 and the country has 3.5 GW installed capacity of hydro power at the end of 2017. For natural gas and crude oil, because of lacking sources the country imports these two. According to Department of Energy, Namibia and Mozambique are the main natural gas supplier for the country, which are border countries with South Africa. For crude oil, Saudi Arabia, Nigeria and Angola is the main countries where South Africa imports mostly.

Figure 28: South African Production/Consumption Data



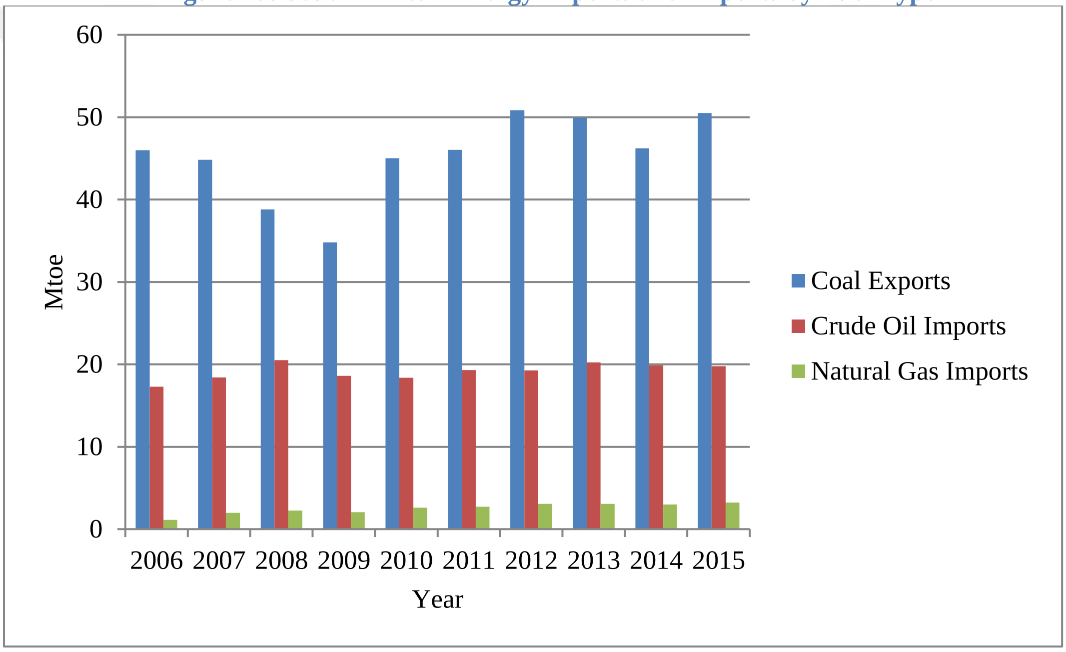
Source: BP, 2017

Figure 28 exhibits the national energy production and consumption quantities in ten years period from 2006. According to BP (2017), South Africa utilizes its coal reserves in high capacity. There is a significant and steady increase in coal production since 1981. In that thirty-five years period production amount approximately doubled. In the beginning it was 74.9 Mtoe and reached 142.4 Mtoe at the end of 2016. In actuality, that was not the highest ever happened in the process. Between 2010 and 2015, each year's production amount was higher than the last year. Especially, with 148.2 Mtoe coal production was the highest ever happened in 2014. Similarly, coal consumption also continuously increased in the same period. When it reached plus 80 Mtoe consumption rates at 2004, never decreased that threshold amount anymore. The highest consumption amount was 93.8 Mtoe in 2009, the reason was the boost started in production side in 2007 and it directly affected the consumption amounts. Between 2007 and 2011, the average consumption was 90 Mtoe.

As it mentioned above, the country has two nuclear reactors. ESKOM is the company which generates approximately %95 of South Africa's electricity. According to ESKOM, there are two 970MW nuclear reactors which are in total 1.9 GW installed capacity. The reactors are located in Koeberg and unit 1 was coordinated to the national grid in 1984 and unit 2 in 1985. It was started with 4.1

TW/hours and reached 15.9 TW/hours at the end of 2016. For oil and natural gas, the country does not have reserves for that both energy sources and imports. South Africa started to use natural gas in the 1980s. In the beginning the consumption was 0.2 Mtoe. Up until 2003, more or less the natural gas consumption was around 0.2 and 1.1 Mtoe. After that year, the consumption amount of natural gas begun to increase steadily. At the end of 2015, it reached 4.6 Mtoe and continued that amount also in 2016. Crude oil consumption threshold level was 20 Mtoe and starting point was 1995. Then the consumption level never decreased that threshold level and approximately 26 Mtoe was the average consumption between 2006 and 2016 (BP, 2017).

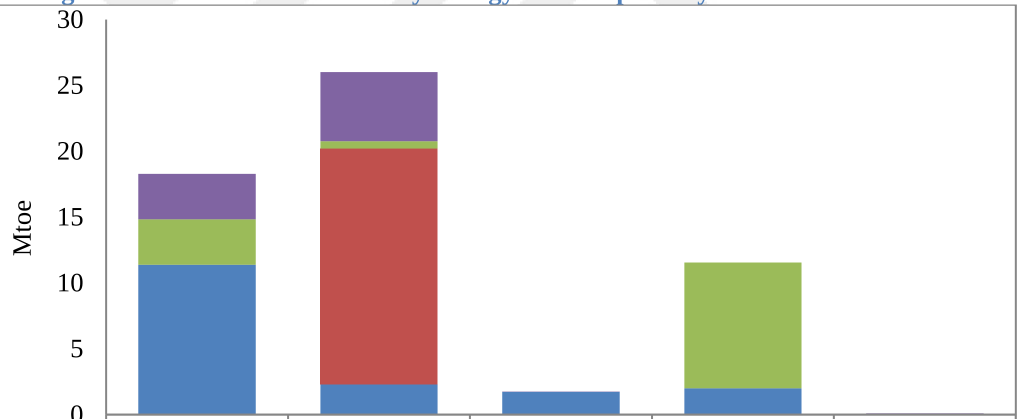
Figure 29: South African Energy Exports and Imports by Fuel Type



Source: IEA, 2018

Figure 29 demonstrates the import/export activities of South Africa between 2006 and 2015. As a result of country's energy policy which is based on the general understanding, to utilize own reserves and try to diversify primary energy consumption with other possible sources. The high reserves of coal are a good asset for the country to export. According to South African Market Insights study (2017); India, China and Netherlands are one of the top countries that coal is exported from South Africa. The highest amount of coal was exported ever in 2012 and 2015 with plus 50 Mtoe which is more than average of the ten year period in the figure. Department of Mineral Resources announced two new goals for the sake of country, especially in coal market. Premier one named as The National Development Plan (NDP) is covers general policy which focuses developments and economic growth from energy sector through adequate investments up to 2030. Second one, which is specifically focused on coal issues, named as South African Coal Road Map (SACRM). That mainly focuses on increasing the revenues from export and increasing the facilities and infrastructure quality. Natural gas and crude oil are the main import subjects of the country. In overall, crude oil imports are higher than natural gas, which is directly related with the energy policy in the country. Since 2003, the country had increased the total consumption of natural gas which is in positive relation with the import amounts. As it exhibited in the figure, natural gas imports steadily increased between the ten years period. In the beginning it was 1.12 Mtoe and increased almost three times and reached 3.23 Mtoe at the end of 2016. On the other hand, crude oil imports are approximately 19 Mtoe in overall with small fluctuations (IEA, 2018).

Figure 30: South African Primary Energy Consumption by Sectors in 2016

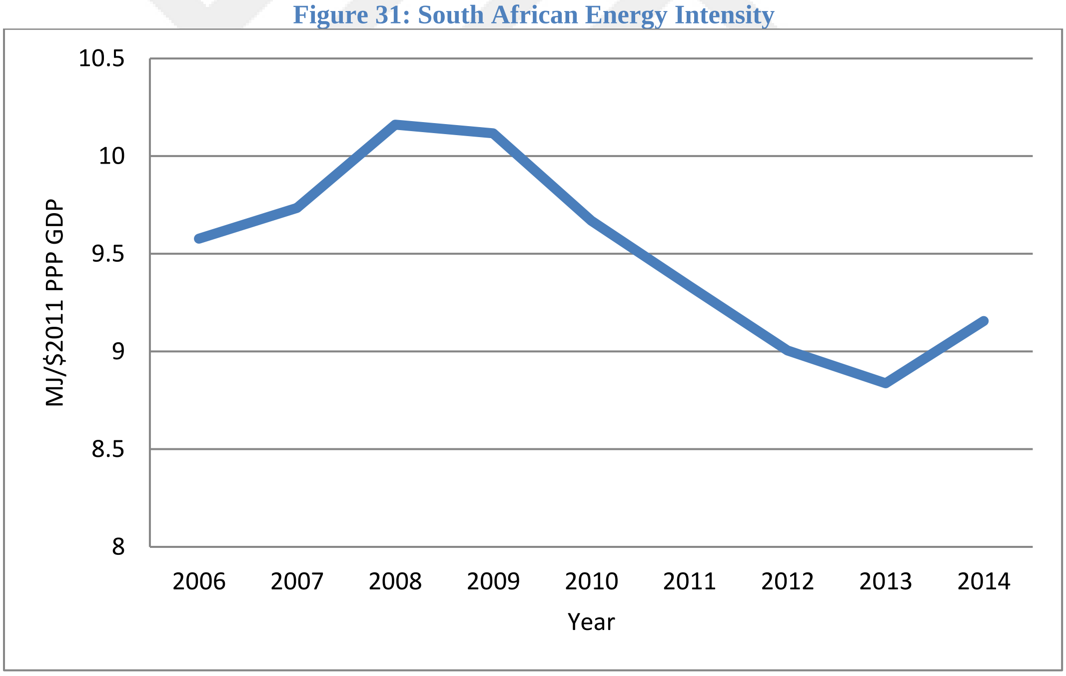


	Coal	Oil Products	Natural Gas	Biofuels and Waste	Geothermal, Wind and Solar
Other	3.458	5.251	0.002		0.113
Residential	3.463	0.572		9.555	
Transport		17.878			
Industry	11.369	2.318	1.741	2.002	

Source: IEA, 2018

According to IEA's sectoral analyzes of energy consumption, for South Africa in particular, other consist of commercial and public services, agriculture/forestry, fishing, non-energy use and non-specified sub categories. Transportation sector had the highest amount among the four sectors with 17.8 Mtoe. Oil products are the main and only supplier of the sector. Industry was the second highest sector with the total 17.4 Mtoe, which was so close to leading sector but unlike it, industry had four different sources which created the total amount. Coal was the highest consumed source by industry and the rest were formed by oil products, biofuels and waste and natural gas. It was followed by residential sector which had 13.5 Mtoe consumption amount. Coal, oil products, biofuels and waste was the sources for residential usage. The highest consumed source was biofuels and waste with 9.5 Mtoe. According to the AFREC (2017), South Africa is one of the top ten countries which are the main producers of charcoal in the continent. In the IEA analysis, biofuels and waste section formed by charcoal usage in the countries. Similar to industry sector, other had the most diversified dispersion of energy sources. The only difference was industry did not prefer geothermal, wind and solar meanwhile other preferred it and did not consume any of biofuels and waste. Between 2011 and 2015, South African energy consumption maintained a distribution among the sectors relatively similar to that shown in Figure 28 (IEA, 2018).

Figure 31: South African Energy Intensity

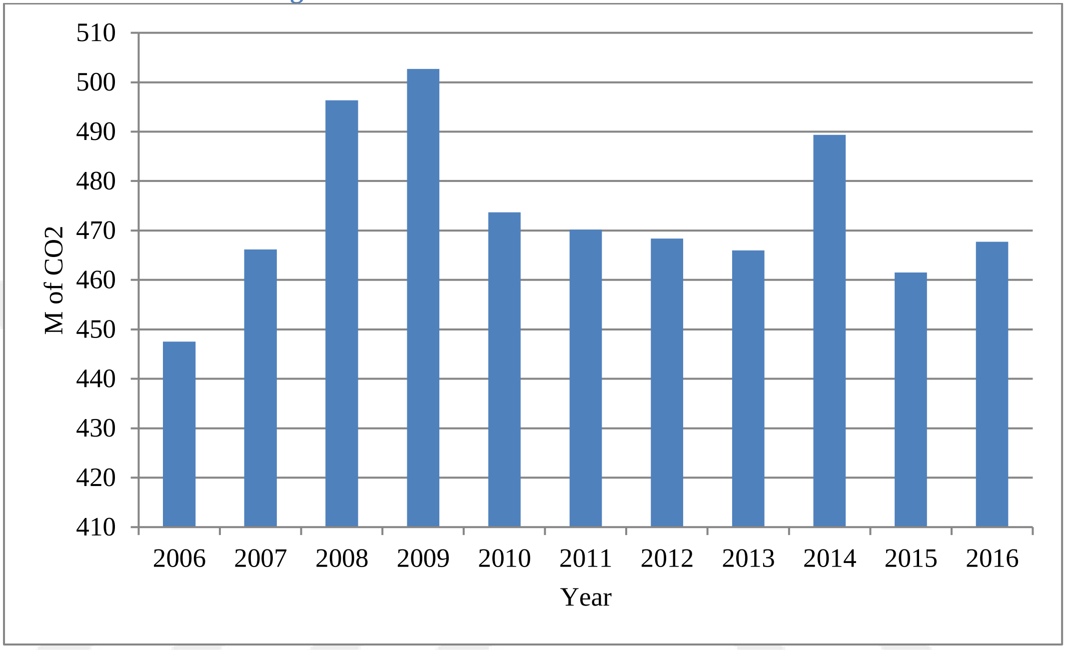


Source: World Bank, 2017

According to WB data sets, in 2014, the energy intensity level of primary energy (MJ/$2011 PPP GDP), for South Africa was 9.16 MJ as at the end of 2014. Similar to other African countries, the country has also high ratio. Before 2006, energy intensity levels of the country fluctuated between 11.4 to 10.4 MJ, in that year first time ever the ratio decreased below overall and never passed again the threshold level, except only in 2008 and 2009. The lowest energy intensity was 8.84 MJ in

2013, and which was a sizeable decrease considering the current situation of the country. In the general perspective, country aims to decrease the ratio and as it demonstrated in the figure, only in the beginning of the nine years period, as an adaptation process, an increase happened. Until up to 2013, the decrease continued steadily (WB, 2017).

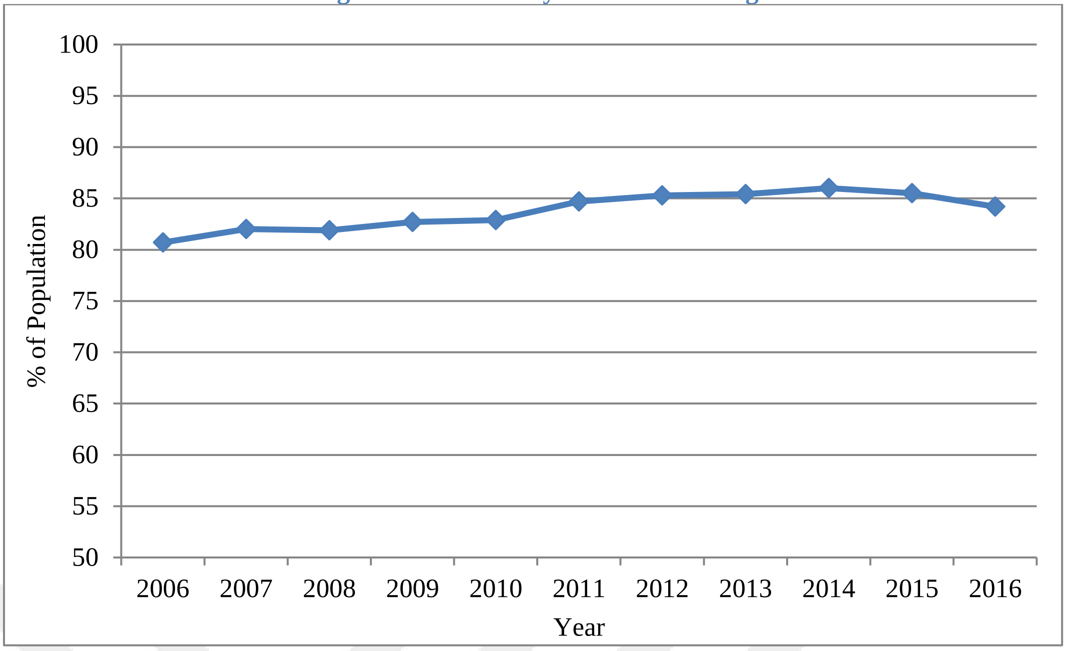
Figure 32: South African Territorial Emissions



Source: www.globalcarbonatlas.org , 2018

South Africa is producing one of the highest amounts of CO2 emissions in the continent. The dominance of fossil fuels, especially coal, in country's primary energy consumption is the reason of current situation. According to Global carbon atlas (2018), the emissions levels have been in a steady increase since 1960. Up until to 2009, this increase continued and reached the peak point with 502 MtCO2, which never happened again. After that threshold year, country decreased emission levels constantly four years in a row. The coal consumption amounts are the main factor for both rise and decline. Similarly, the overall consumption increased in 2009, 2014 and 2016 which directly reflected on the emission levels as a step-up. This is valid for also the declines in overall emissions. On the contrary that country aimed to decrease CO2 emissions, in the beginning of the ten years period it was 447MtCO2 and did not pass below the threshold level, was 467 MtCO2 at the end of 2016.

Figure 33: Electricity Access Percentage



Source: World Bank, 2017

South Africa has a population of 56 million people at the end of 2016. The country has one of the highest accessibility ratios in the continent and aimed make it 100% together with the main supplier of the country, which is Eskom Company. Since 1990, the overall electricity access steadily increased. In the figure, unlike the decrease points for instance, one happened from 2007 to 2008, the other one between 2014 and 2016. The reason was the increase in the population of the country. According to data sets, in average approximately 8 million people are lacking of access to electricity. Some parts of the country are off the national grid and this is the focus point for both country and the company Eskom (WB, 2017). According to Eskom 2017 – 2018 Tariffs and Charges Report, there are sixteen different classes for customers. NightSave for urban large and urban small, MegaFlex, MegaFlex Gen, MiniFlex, BusinessRate, PublicLighting, HomePower bulk and standard, HomeLight, NightSave for rural, RuraFlex and RuraFlex Gen, LandRate, LandRate Dx and LandLigth. In general, the differences between the classes are location, maximum demand, high – low voltage and usage styles. There is a sample bill from 04.09.2017 in the appendix-A section, which was cost 320 South African Rand (ZAR) for 154.4 kWh, considering the XE website currency rates it was 24.69$.

CHAPTER 6

BENCHMARK COUNTRIES

Australia, Kazakhstan and Norway are the selected countries to compare and contrast the African countries' energy security situation. Each country is a representative of different parts of the world. Australia is from Oceania region and selected owing to its' high reserves of coal. Kazakhstan is a country in the Central Asia, and one of the highest producers in the region. Lastly, Norway is in Northern of the Europe and one of the top ten net producers and exports of natural gas in the world. Australia and Norway already applied some laws and acts for decreasing greenhouse gas emissions and increasing the effectiveness of renewables in the country. Kazakhstan is planned to increase its' hydro consumption at first and then they will focus on solar power possibilities to increase diversification in the country with an agreement of European agencies. Similar to African countries, the analyses with indicators are in same order. General information, primary energy consumption by fuel types for to indicate diversification, the reserves and existing power plants for availability, imports and exports amounts for demonstrate the dependency in the country. Sectoral consumption to examine which energy source for which sector, kind of a deeper analyze of energy diversification. Energy intensity level and carbon emissions to demonstrate how much and in which way the general energy policy is affecting country's current situation. The electricity prices to show the affordability and the chart for accessibility of electricity. Countries are analyzed in an alphabetical order.

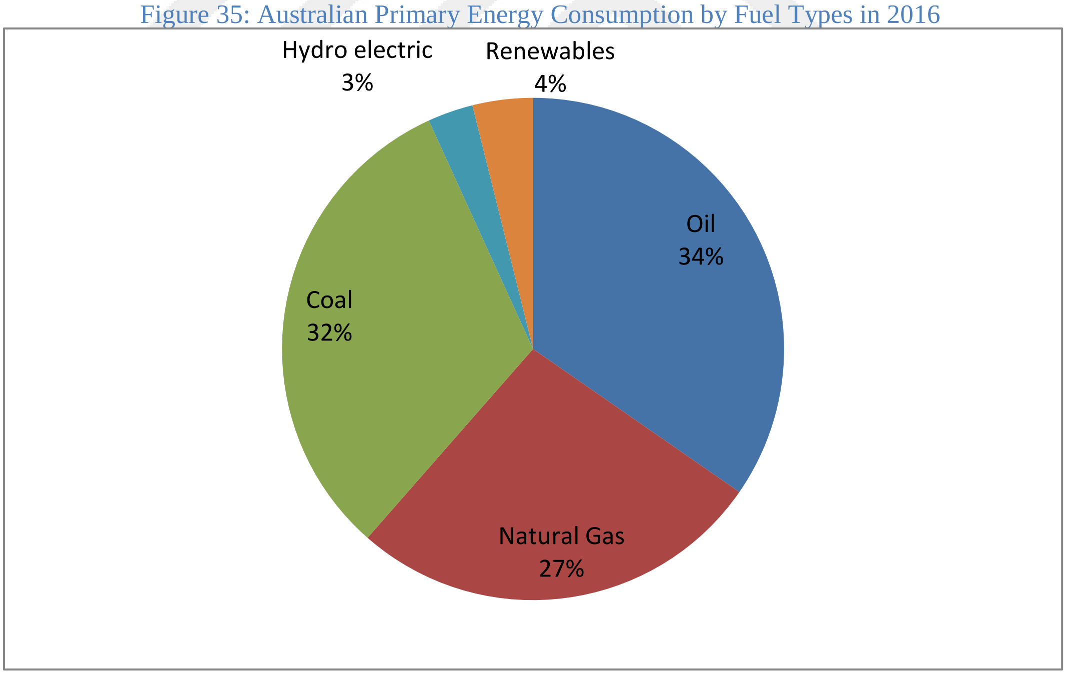
Beginning with Australia, the country has one of the highest coal reserves in the world. They utilize coal both in production and exportation. Mainly, three fossil fuels are forming the overall consumption in the country. On the other hand, hydro and renewables share are almost 10% in total. Due to its' geographical location countries main export destinations are mostly from Southeast of Asia. Japan and China are the two major importers of Australian coal and natural gas. More than twenty-eight years, country provides electricity accessibility of its' citizens.

6.1 Analysis of Australia

Figure 34: Australia in the world map source: http://www.countryreports.org/

Australia, formally known as The Commonwealth of Australia, is an island country comprising the mainland of the Australian continent. There are numerous smaller islands such as; Lord How e and Macquarie. The continent and the country Australia is in between the Indian and the South Pacific Ocean. The country is covering an area of 7.741.220 square kilometers and has one of the longest coastlines in the world, which is 25.760 km. Australia has a population over 24 million people and Canberra is the capital city of the country (CIA, 2017).

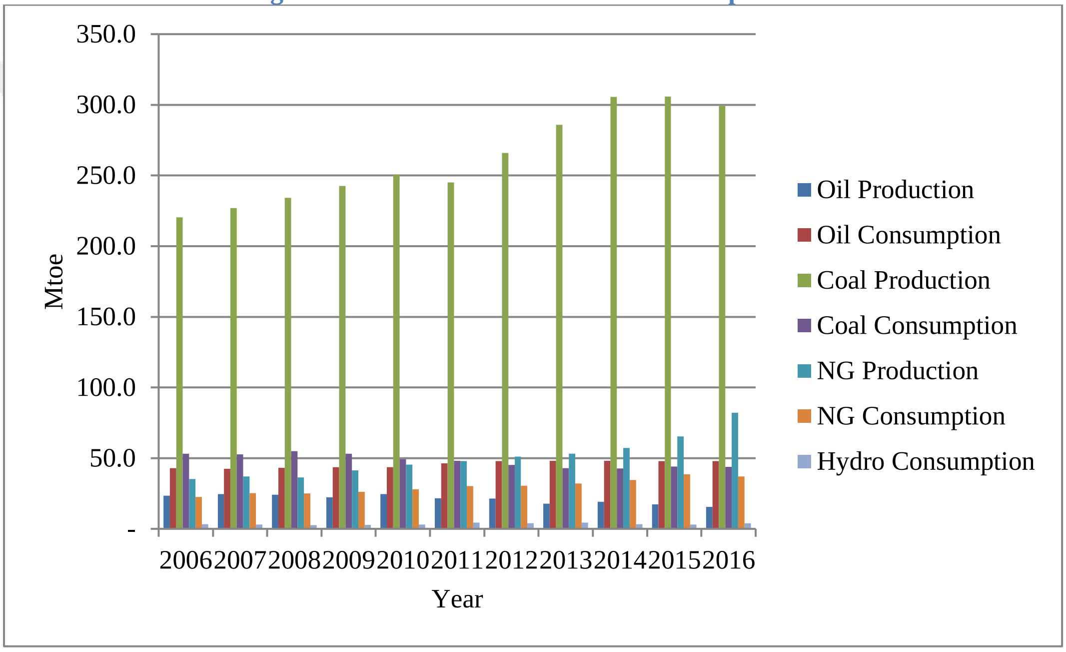
Figure 35: Australian Primary Energy Consumption by Fuel Types in 2016



Source: BP, 2017

According to BP data sets, fossil fuels are forming the majority, approximately 93% of Australian primary energy consumption. Hydro electric and renewables are forming the rest. The country's total consumption was 138 Mtoe at the end of 2016. Roughly, the final consumption amounts of fossil fuels are close to each other and crude oil is leading with 47.8 Mtoe. Hydro and renewable are forming approximately 10 Mtoe. Australia has 0.4 billion tonnes of oil, 3.5 trillion cubic meters natural gas and 144.818 million tonnes of coal proven reserves (68.310 anthracite and bituminous, 76.508 sub-bituminous and lignite). According to Australian Renewable Energy Agency (ARENA), the country has 120 operating hydroelectric power stations and supplied 17.9 TW/hours in 2016 and total installed hydropower capacity is 8.8 GW including with 1.3GW pumped storage. Australia has 5.4 GW solar installed capacity, 4.5 GW wind installed capacity, the total consumed amount from solar was 7.2 TW/hours electricity and 13.2 TW/hours from wind.

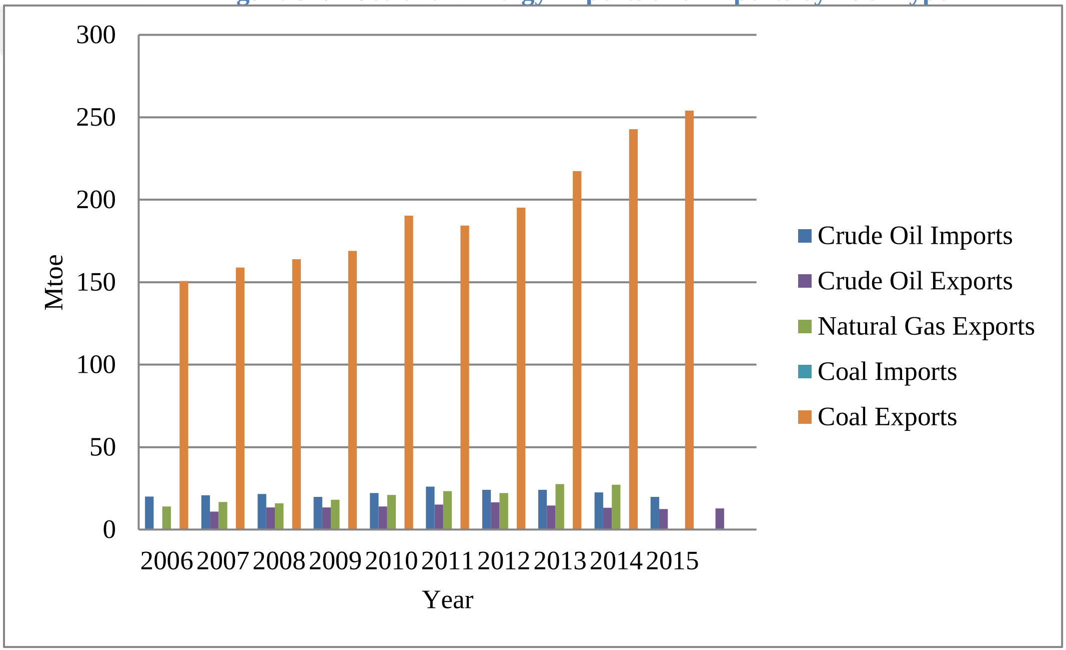
Figure 36: Australian Production/Consumption Data



Source: BP, 2017

Australia has fourth largest coal reserves in the world, the top three countries are USA, China and Russia in order. The reflection of its reserves to production sector also, Australia is one of the top five country main producing countries in the world (IEA, 2017). In the figure 36, it is exhibited that obviously coal dominance in the statistics and overall production amounts in the country. There are two important and transition years for Australia. First one is 2009, gradually increase in both consumption and production natural gas and decrease in coal consumption from 54.9 to 53.1 Mtoe. Second one is 2011, progressively the country declined coal production from 250.6 to 245.1 Mtoe and oil production from 24.5 to 21.5, simultaneously increase in oil consumption. Australia utilized coal as a supportive controller in the changes of general energy policy. Since 2009, the overall coal consumption steadily decreased and reached 43.8 Mtoe. Concurrently, natural gas production increased approximately two and half times, was 82 Mtoe at the end of 2016. In that ten years period, oil production and coal consumption shifted to boost in coal and natural gas production, also consumption, in overall. Meanwhile, Australia kept the hydroelectric and renewables contribution more or less in similar amounts what they have in general. In other words, in the beginning of ten years period, overall production amount of fossil fuels and hydro was 282.6 Mtoe and rose to 400.8 Mtoe in 2016. Total consumption amount was 122 Mtoe and increased to 132.6 Mtoe (BP, 2017).

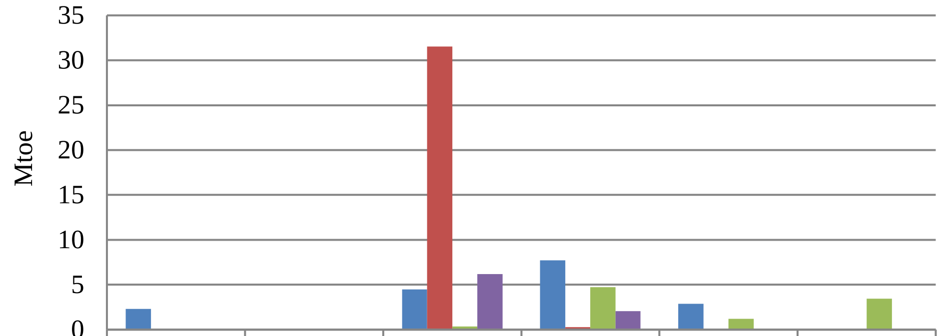
Figure 37: Australian Energy Exports and Imports by Fuel Type



Source: IEA, 2018

Australia highly utilizes its coal reserves in both national supply and also major element of exports. The transition years of energy policy in the country, it also affected the overall imports and exports. The first transition year, which is 2009, steadily an increase in natural gas both production and consumption and a decrease in coal production. That was the main reason for Australia to increase overall natural gas imports since first transition year and remained the coal exports exponentially. The growing natural gas productions increased the overall exports of the country. Southeast Asia is the main region that Australia exports both its natural gas and coal. Clearly, the reason is their geopolitical position and its direct effect to country's policies. According to Australian Department of Environment and Energy, Japan was the largest liquefied natural gas (LNG) importer in 2016. Furthermore, beside Japan, China and India is named largest coal importer from Australia. Natural gas exports increased approximately four and half times since the transition year and reached 5.14 Mtoe at the end of 2015. In the second transition year, coal exports declined from 190.39 to 184.4 Mtoe as result of decrease in total production. For crude oil, the country kept both imports and exports in balance from 2006 to 2015, while having changes in this nine year period (IEA, 2018)

Figure 38: Australian Primary Energy Consumption by Sectors in 2015

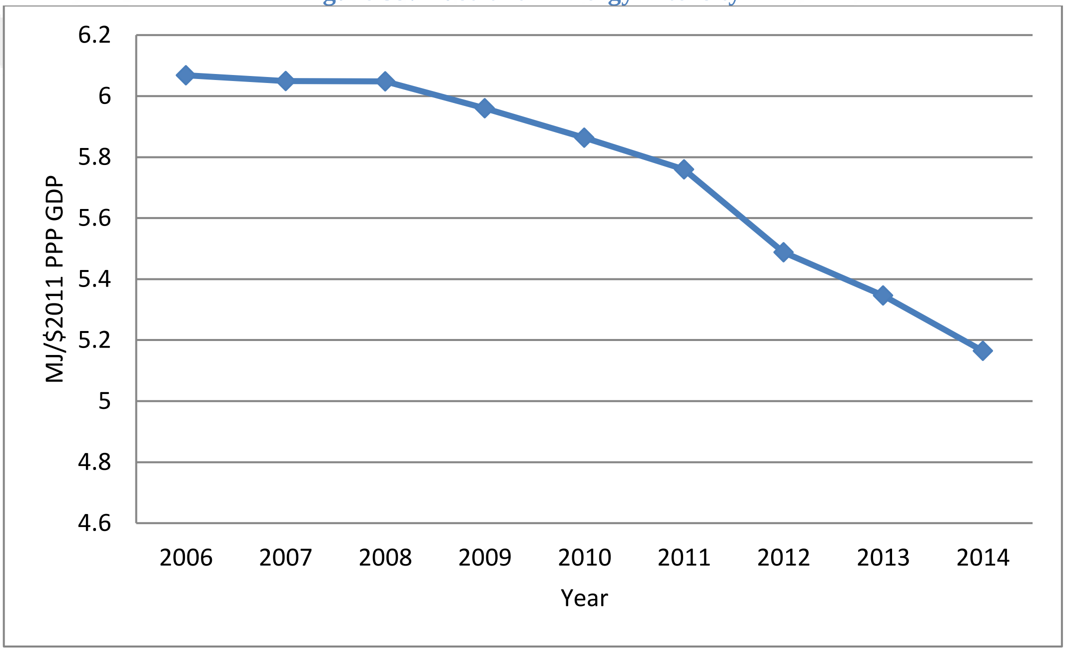


	Coal	Crude Oil	Oil Products	Natural Gas	Biofuels and Waste	Geotherma l Wind and Solar
Industry	2.322	0.016	4.475	7.707	2.871	
Transport	0.001		31.532	0.268		
Residential	0.001		0.369	4.729	1.19	3.45
Other	0.007		6.182	2.05	0.046	0.01

Source: IEA, 2018

According to IEA’s sectoral analysis of energy consumption, for Australia in particular, the other category consists of commercial and public services, agriculture/forestry and non-energy use sub-sections. The transportation sector is the leading among the four, with 31.8 Mtoe. Oil products are the main supplier of this sector (with almost 99% of total consumption), coal and natural gas have insignificant effect to the sector. This sector has the least dispersion with only three of six energy sources. Industry is the second highest sector with a total amount around 17.3 Mtoe. This sector utilized five different energy sources in total and natural gas has the biggest impact among them. Similar to industry sector, residential and others have also five diverse energy source which means these three sectors have a quite proportional dispersion. Only difference is that industry preferred crude oil while the others and residential utilized geothermal, wind and solar. Residential and other sectors consumed approximately similar amount with industry. Other has the lowest amount of consumption with 8.2 Mtoe.   Australian sectors' total consumption was 67.2 Mtoe in 2016. Fossil fuels have effect to all sectors in the country. Coal and natural gas are responsible for industry and unquestionably oil products are have majority in transportation sector and also other. Renewables, which are geothermal, wind and solar, are mostly utilized by residential sector. Industry also consumed more than half of the biofuels and waste. Between 2011 and 2015, Australian energy consumption maintained a distribution among the sectors relatively similar to that shown in Figure 36 (IEA, 2018).

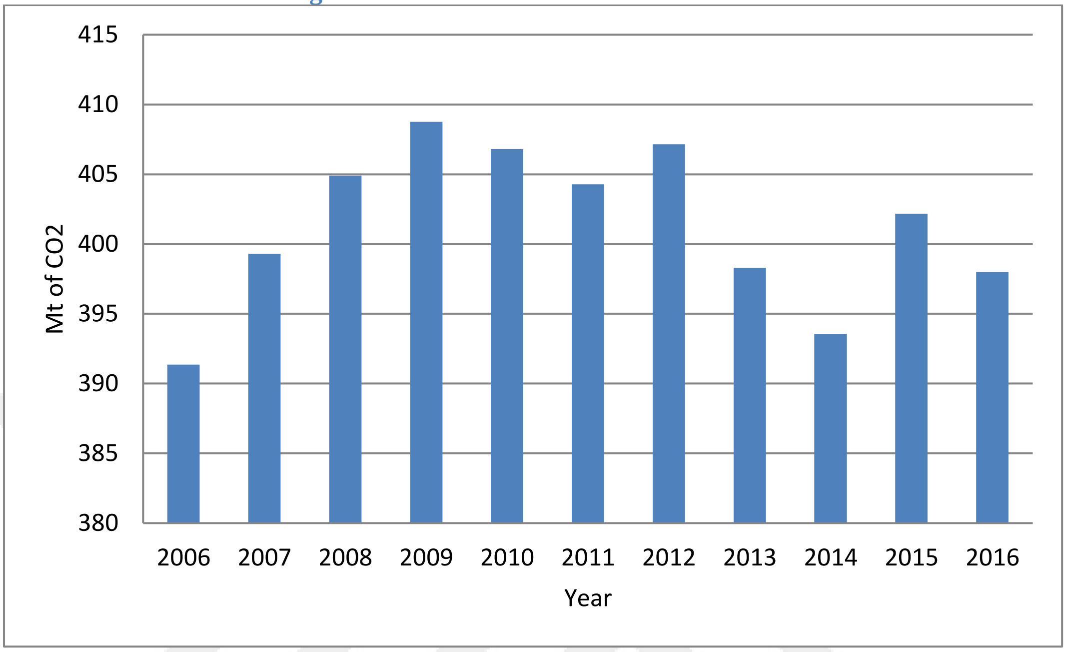
Figure 39: Australian Energy Intensity



Source: World Bank, 2017

According to WB data sets, the energy intensity level of primary energy (MJ/$2011 PPP GDP), for Australia was 5.1 MJ as at the end of 2014. The country intensity levels are steadily in a downtrend since 1990. Simultaneously, country increased the overall production and consumption amounts. Especially with the first transition year a sharp decline happened up until to 2014 and also second transition year's effect remained the falling rate, which was in average 0.14 MJ/$2011. According to Department of Environment and Energy report, with economical developments in the country, the profile has been shifted to lower intensity rates with higher productivity. Two specific detail given also, first one is the energy productivity increased approximately 2 per cent in average and second one is while gradually increasing natural gas production, LNG exports increased significantly (WB, 2017).

Figure 40: Australian Territorial Emissions in



Source: www.globalcarbonatlas.org , 2018

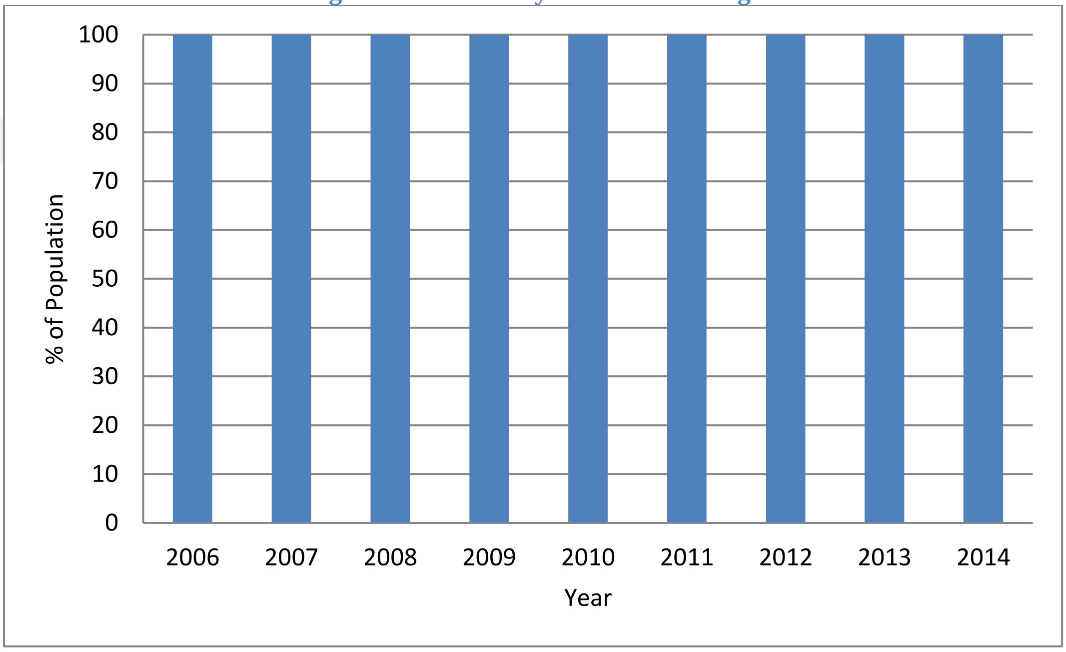
Australian Clean Energy Regulator (CER) institution, which is an independent statutory authority responsible for administering legislation to reduce carbon emissions and increase use of clean energy, is managing, measuring, reducing and or offsetting the carbon emission in the country. The country has four special regulations for greenhouse gas and CO2 emissions;

- Renewable Energy Act 2000
- National Greenhouse and Energy Reporting Act 2007
- Carbon Credits Act 2011
- Australian National Registry of Emissions Unit Act 2011

CER have administrative responsibilities for these four regulations. The overall emissions are analyzing under three different scopes. Scope 1, is responsible for emissions from; electricity production, fugitive emissions, diesel fuels and manufacturing process. Scope 2, is responsible for the emissions that created in scope one, in particular electricity production, and continued to release to atmosphere under different condition and scope 3 covers continuing emissions from scope two.

According to Global Carbon Atlas data sets, Australia is in uptrend of emissions as always but with not high amounts in average. In particular, first transition year was the peak point, which is never repeated again, for emissions as a result of increasing both natural gas and coal production. 2010 and second transition year were the beginning of decrease of the emissions because of the decline in both coal and oil consumption. In overall, electric supply was responsible for more than half of the emissions in the country under scope 1. Mining industry, manufacturing, transportation and other were forming the rest.

Figure 41: Electricity Access Percentage



Source: World Bank, 2017

Considering to WB data sets, Australia reached 100% electricity accessibility rates at the end of 1990. The country has a population of over 24 million people at the end of 2017. Since that year the accessibility rate have never changed in Australia. The population was 17 million people in 1990 and increased more than 7 million in twenty-seven years. Australian National Electricity Market (NEM) incorporates around 40.000 kilometers of transmission lines and cables to provide electricity for citizens. NEM interconnects five regional markets of the country; Queensland, New South Wales, Victoria, South Australia and Tasmania. Northern and Western parts of Australia having its own transmission and distribution lines (WB, 2017). According to the Standard Electricity Prices and Charges report of Synergy, this is the largest energy supplier of Western Australia; there are six different residential tariffs, seven different business tariffs and three different tariffs for the customers with specific needs. The distinctions between the tariffs are the consumption fees for the time periods and charges for the amount of usage. On the other hand, the consumption fees are calculating in daily usage. For example, with the similar total consumption amount of Algerian bill, for 340kWh usage with Synergy Home Plan tariff (A1), approximately equals to 49 Australian Dollar (AUD) for monthly which was 37$.

6.2 Analysis of Kazakhstan

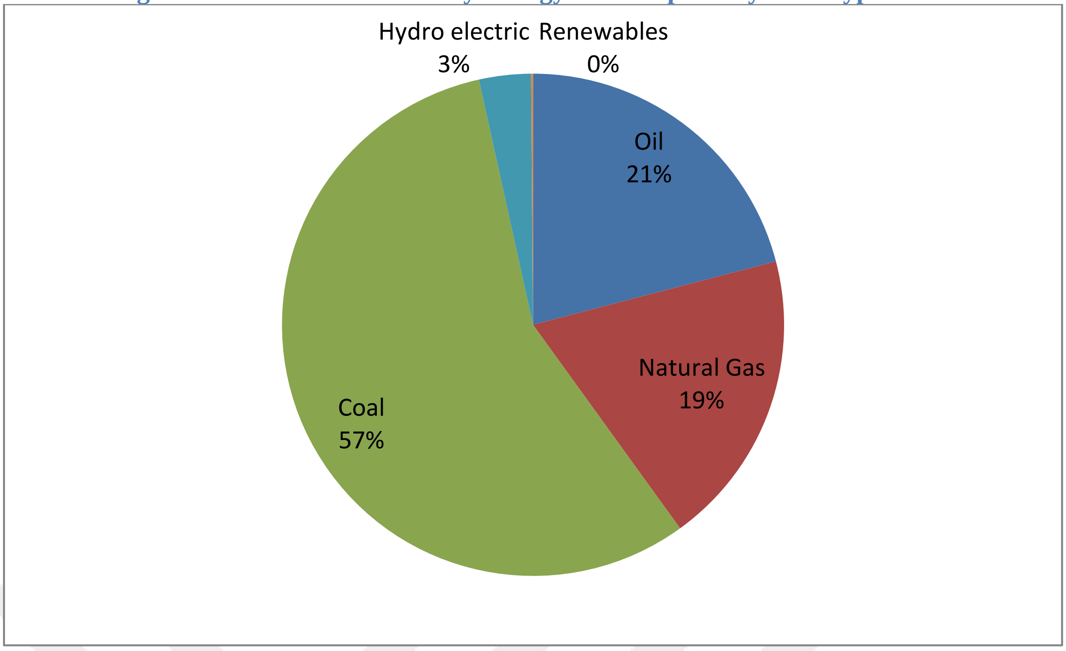
The country is the world's largest landlocked country with more than 2.5 million square kilometers. Kazakhstan mostly utilizes its coal reserves and even though being one of the largest producer and exporter of coal, in countries overall exports, crude oil exports are more than coal (IEA, 2017). In order to increase diversification of energy sources in the country, Kazakhstan made an agreement with European Bank for Reconstruction and Development (EBRD). According to that agreement, firstly the hydro power plants utilization will be increase until to 2020 and then solar power will be another option for the country. Kazakhstan had reached 100% accessibility rates at 2009 but due to some infrastructure challenges it was decreased around 0.5% until to 2014 and then with developments and restorations it was accessible by all citizens.

Figure 42: Kazakhstan in the world map
source: http://www.countryreports.org/

Kazakhstan, formally known as the Republic of Kazakhstan, is a country in the Central Asia. It shares borders with China, Kyrgyzstan, Turkmenistan and Uzbekistan in the south, Russia in the north and Mongolia in the east of country. The country has a coastline to the Caspian Sea in the west and also coastline to Aral Sea along the border with Uzbekistan in the south. Kazakhstan covers an area of 2.724.900 square kilometers and has a population of more than 18 million people. Astana is the capital city of the country (CIA- the World Factbook, 2017).

According to BP data sets, Kazakhstan's primary energy consumption is almost formed by fossil fuels. Hydro electric, nuclear and renewables have insignificant effect. The country's total consumption was 63 Mtoe at the end of 2016. Roughly, the final consumption amounts of natural gas and crude oil are close to each other and coal is leading with 35.6 Mtoe. Hydro and renewable are forming approximately 3.2 Mtoe.

Figure 43: Kazakhstan Primary Energy Consumption by Fuel Types in 2016

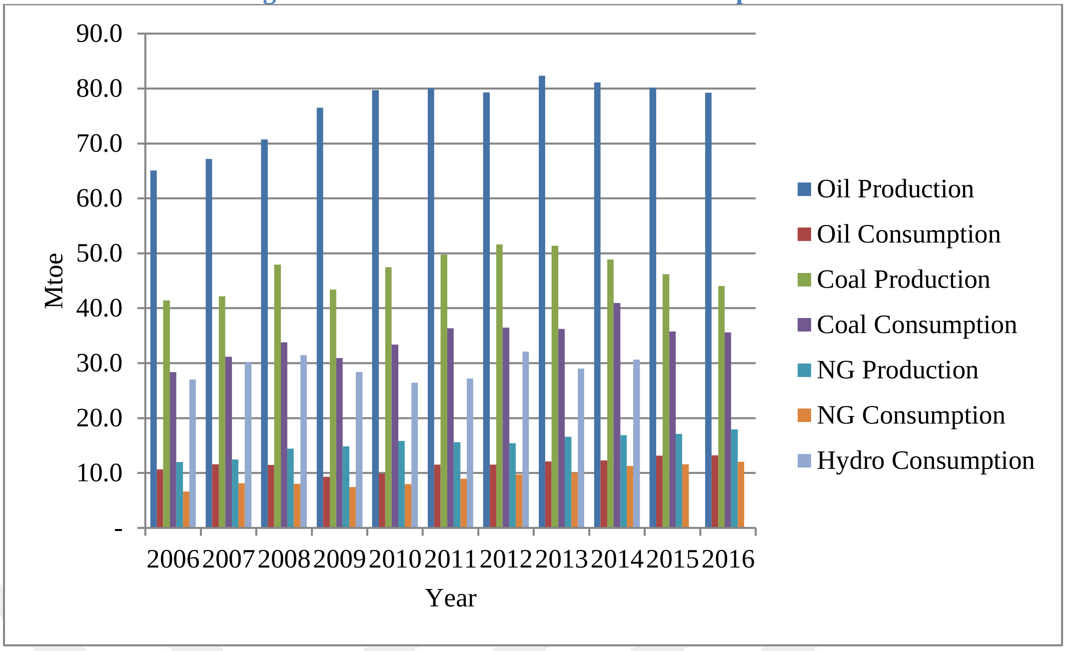


Source: BP, 2017

Kazakhstan has 3.9 billion tonnes of oil, a trillion cubic meters natural gas and 25.605 million tonnes of coal proven reserves (25.605 anthracite and bituminous). According to EBRD, the country has 15 operating hydroelectric power stations and supplied 9.3 TW/hours in 2016 and total installed hydropower capacity is 2.2 GW. Solar power potential of the country is estimated between 4 to 5.5 TW/hours, which is approximately 5% of annual consumption. According to the Ministry of Energy, Kazakhstan planned to increase current insufficient solar power capacity to 713.5 MW total installed capacities at the end of 2020. For wind energy, although the country has a fairly enough sufficient wind speed through the continental climate conditions and its geographical location, which is something a future possible solution because of some technological (access to national grid) and logistical challenges.

Kazakhstan is one of the top ten world largest coal producer and net exporter country (IEA, 2017), which is a through result of its proven reserves and main energy policy of the country. In the figure 43, oil production amount is always higher than coal and natural gas production since 2005. In the beginning, oil production was 65.1 and increased to 79.3 Mtoe and consumption was 10.7 and increased to 13.2 Mtoe with small fluctuations. The highest overall fossil fuel production amount was 150.3 at the end of 2013.

Figure 44: Kazakhstan Production/Consumption Data

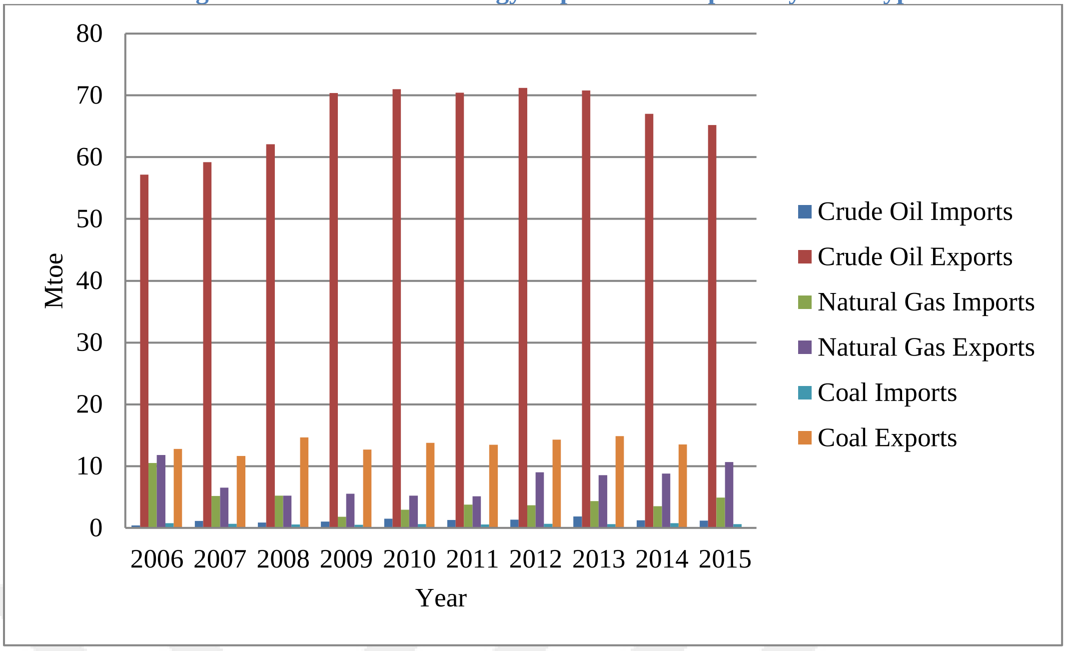


Source: IEA, 2018

In addition, this was a peak year for oil at the same time coal started to decrease gradually. Until to the peak year, simultaneously both coal and oil was steadily increased, except 2009 for coal and 2012 for both. Although the consumption of these sources was continuously increased, coal production and consumption amounts began to decline since 2012. On the other hand, natural gas both production and consumption steadily increased. The production amount was 12 Mtoe in 2006 and reached 17.9 Mtoe at the end of 2016. Natural gas consumption almost doubled in that ten year period, which was 6.6 Mtoe and increased to 12 Mtoe at the end of 2016. The hydro consumption of country was also increased (BP, 2017).

The country utilizes its proven fossil fuel reserves in both national supply and main asset for exportations. As it mentioned above that, Kazakhstan is one of the net coal exporter country in the world. Compared to its crude oil exports, coal can be seen not so large amounts but in the sector it is quite sufficient for the country. According to Kazakh Energy Minister, Kanat Bozumbayev, the country exports coal to *"First of all, Russia, Central Asia and several European countries this year (2017), a good amount coal – more than 2.4 million tonnes – was exported to Finland."* Japan will be added as a new destination to export coal in the upcoming years. From 2006 to 2015, overall coal exports increased from 12.79 to 13.65 Mtoe with some fluctuations in the period.

Figure 45: Kazakhstan Energy Exports and Imports by Fuel Type

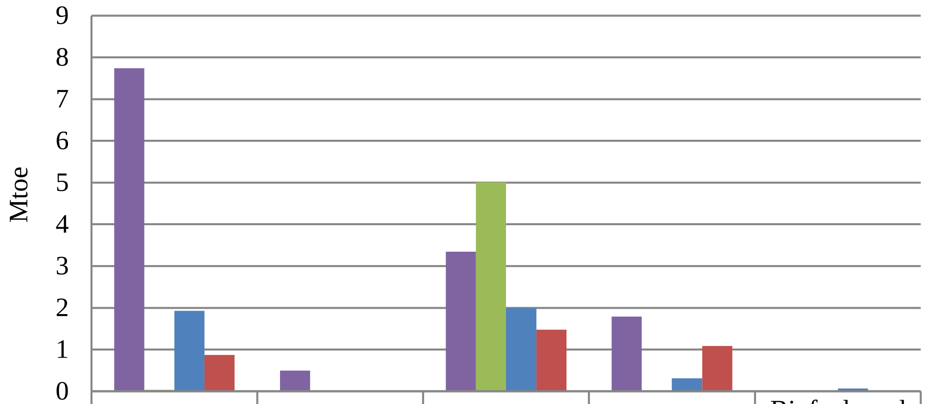


Source: IEA, 2018

Crude oil is leading exportation energy source for Kazakhstan. The pipeline system is operated by KazTransOil (KTO), which is a subsidiary of KazMunaiGas (KMG). The country is still using the infrastructure and facilities which remained from Soviet-era and the because of its landlocked location pipelines are the main export route. In addition, the country utilizes Caspian Sea as a second route. Germany and France imports more than 10% of coal, Italy, Greece and China are the other major importers from Kazakhstan. In the figure, up until to one year before of the peak year, Kazakhstan's crude oil exports continuously increased to 71.2 Mtoe and then started to decrease and fall 65.18 Mtoe. Due to similar reason, the country has lack of access to open sea and ocean routes, as a result of this, natural gas dependent on the pipelines. China is the largest country that Kazakhstan exports and, Kazakhstan place as a transit country for China both oil and natural gas. Turkmenistan and Uzbekistan are the countries where Kazakhstan mostly imports natural gas (EIA, 2017; 2018).

According to IEA's sectoral analysis of energy consumption, for Kazakhstan in particular, the other category consists of commercial and public services, agriculture/forestry and non-energy use sub-sections. The industry sector was the leading among the four, with 13.3 Mtoe. Coal was the main supplier of this sector with more than half of the total. Oil products, crude oil (which utilized only in this sector) and natural gas formed the rest.

Figure 46: Kazakhstan Primary Energy Consumption by Sectors in 2016



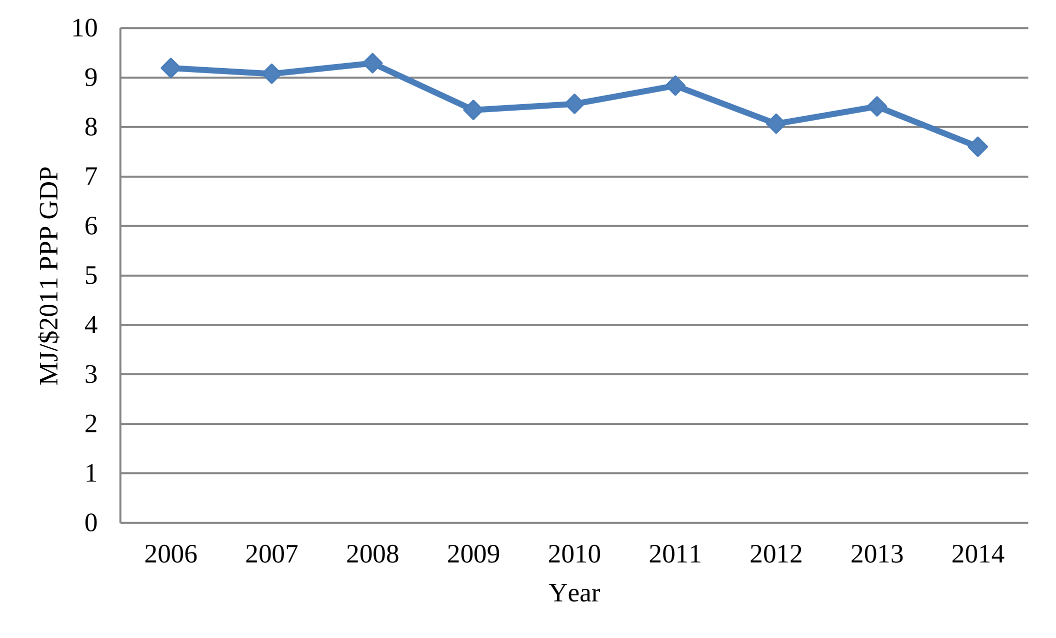
	Coal	Crude Oil	Oil Products	Natural Gas	Biofuels and Waste
Industry	7.741	0.499	3.344	1.786	
Transport	0.036		5.005		
Residential	1.931		1.998	0.313	0.07
Other	0.874		1.473	1.087	

Source: IEA, 2018

Transportation was the second highest sector with a total amount more than 5 Mtoe. Oil products were the main supplier of this sector, almost 99% of total and coal had insignificant effect. Residential sector was the only one which utilized biofuels and waste, though which had small impact to overall 4.3 Mtoe. Other consumed the least amount among the four sectors with 3.4 Mtoe in total. Residential and industry sectors were most diversified which utilized four of five main energy sources. The only difference was while industry consumed crude oil, residential preferred biofuels and waste. Transportation sector was the least diversified with only consuming two of five. Kazakhstan sectors' total consumption was 26 Mtoe in 2016. Between 2011 and 2015, Kazakhstan energy consumption maintained a distribution among the sectors relatively similar to that shown in Figure 44 (IEA, 2018).

According to WB data sets, the energy intensity level of primary energy (MJ/$2011 PPP GDP), for Kazakhstan was 7 MJ as at the end of 2014. The country intensity levels are steadily in a downtrend, which decreased approximately half size since 1990.

Figure 47: Kazakhstan Energy Intensity

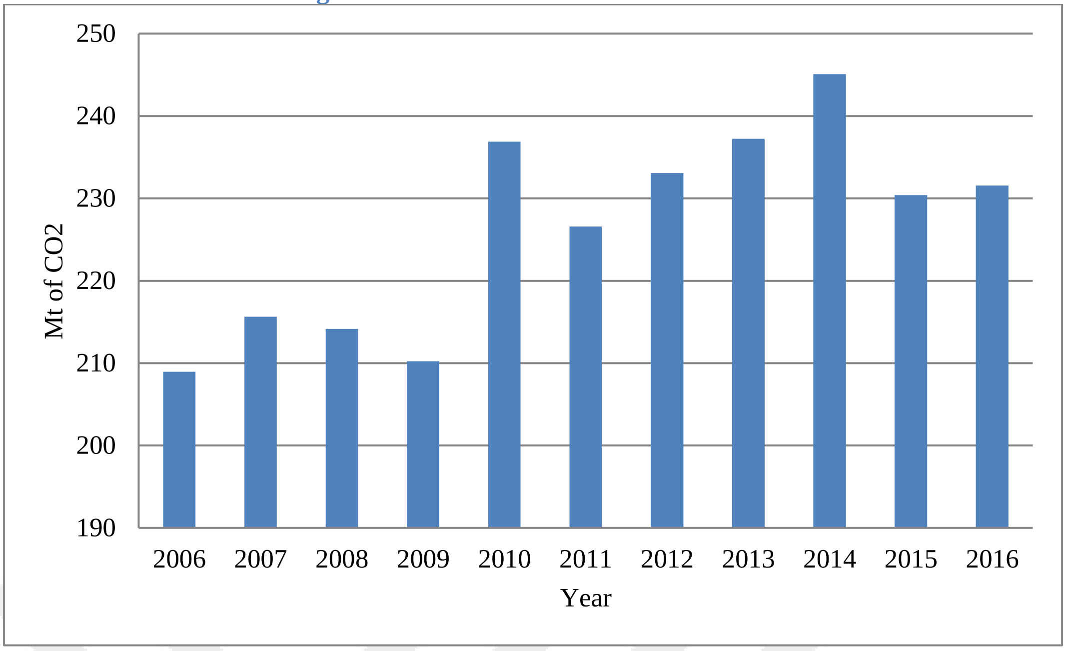


Source: World Bank, 2017

Simultaneously, country increased the overall production and consumption amounts. Kazakhstan's First Vice Minister of Investment and Development, Alik Aidarbayev said that*" All required laws were adopted and signed. The national energy register was also approved, which includes more than 5,000 companies that are obliged by law to conduct an energy audit, develop a plan and work towards decreasing energy intensity."* He underlined that, the country analyzed and worked on experience that Japan for energy saving policies and energy intensity of Kazakhstan decreased 28% since 2008. They aimed to add 25% more up to 2020 and reach 50% by 2050 under the defined policies (WB, 2017).

Kazakhstan is fully committed to the United Nations Framework Convention on Climate Change (UNFCCC), which is an international treaty and adopted in 1992. This has a global legally binding agreement to all parties at the Paris Conference in 2015. In order to decrease overall carbon emissions in the country, they aimed to utilize renewables more than current conditions, apply technological developments for existing fossil fuel facilities and gradually decrease total consumption of oil, coal and natural gas. Kazakhstan set up the targets for both 2020 and 2050 and made agreements with EBRD to utilize its high solar irradiance. According to IEA data sets, the country is downtrend in coal since 2013, which was the peak production year for the country.

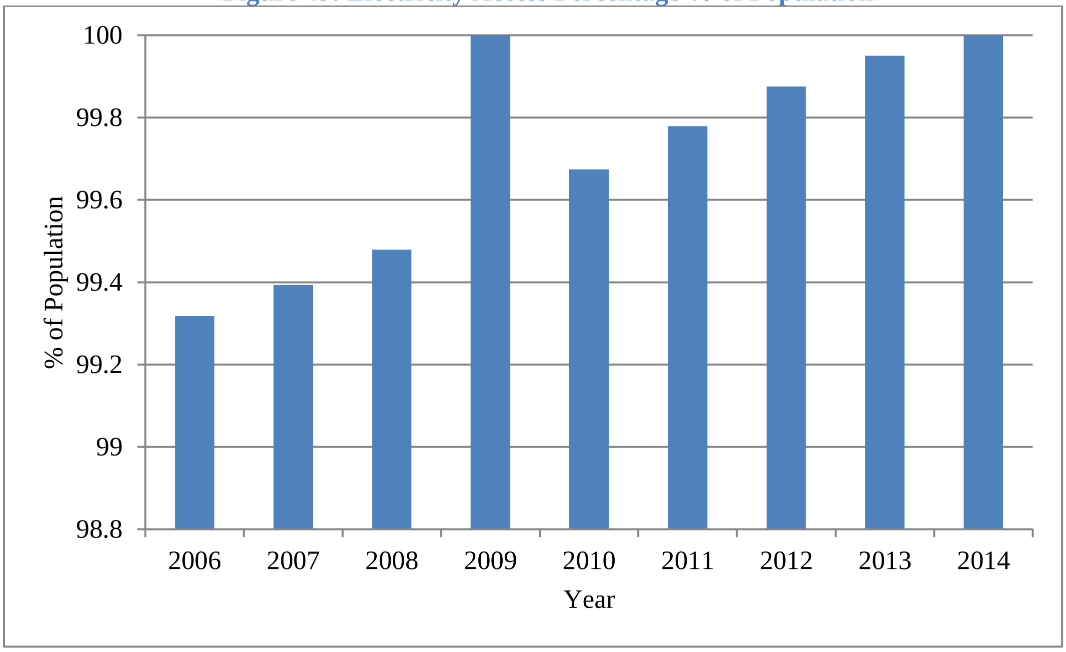
Figure 48: Kazakhstan Territorial Emissions



Source: www.globalcarbonatlas.org , 2018

Furthermore, analyzed and examined also the wind condition and but at first the country should focus on solar first and then increase facilities with technological developments to benefit from the wind energy. The country aimed to decrease between 15 to 25% of carbon emissions by 2030 compared to 1990, under the binding element of Paris agreement which is Intended Nationally Determined Contributions (INDC).

Figure 49: Electricity Access Percentage % of Population



Source: World Bank, 2017

According to WB data sets, even though Kazakhstan reached 100% electricity accessibility rates at the end of 2009, due to harsh climate conditions some parts of the country faced with some connection challenges to national grid. Approximately less than 1% of the population had some blackouts and or lack of access to electricity from 2010 to at the end of 2013. Kazakhstan reached again 100% accessibility rates in 2014 with improvements and developments in troubled territories. The total population was around 15.3 million people in 2006 and increased to 17.7 million people at the end of 2016 (WB, 2017). Kazakhstan Electricity Grid Operating Company (KEGOC) announced the tariffs in its website, which are valid since 2015. Considering to that information; 1.943 tenge/kWh for electricity transmission, 0.182 tenge/kWh for technical dispatching of electricity delivery and consumption in the grid and 0.083 tenge/kWh for electricity generation and consumption balancing, excluding of VAT, Kazakhstani Tenge is the currency of the country (KEGOC, 2018).

6.3 Analysis of Norway

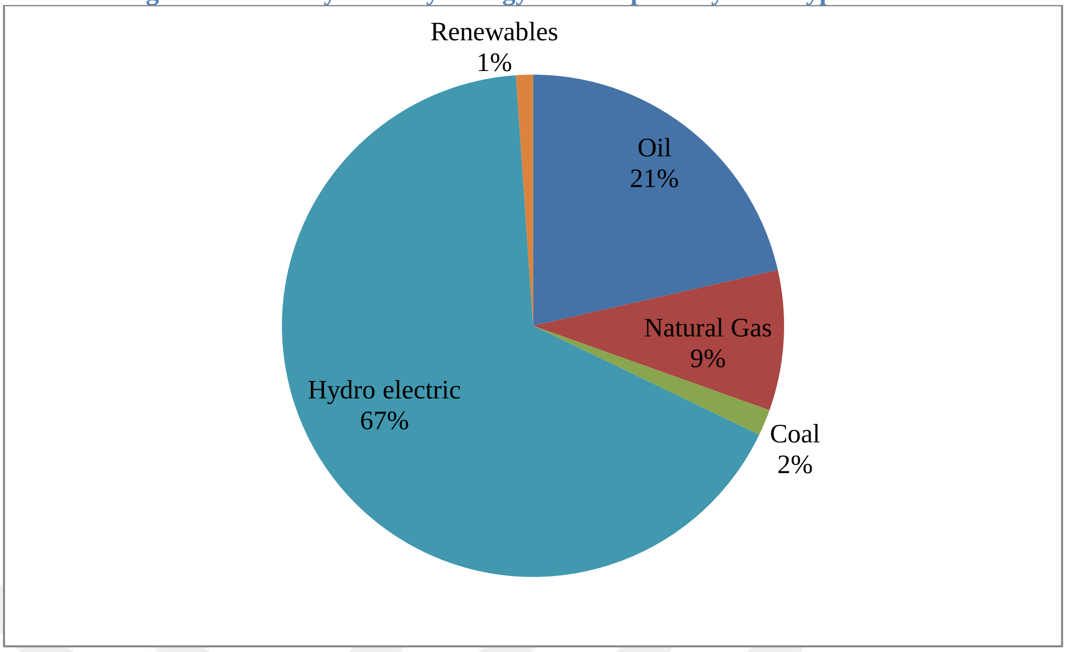
Norway is both one of the largest hydro and natural gas producer country in the world. The country's hydro power is more than 30 GW installed capacity and generated 144 TW/hours electricity, which is the highest amount ever, in 2016. Beside the hydro power, crude oil and natural gas the other sources that Norway utilizes. Until 2010, country gradually decreased its crude oil production and increased natural gas, which was a policy change, as a shift from one source to another. Norway exported 115bcm natural gas in 2016 and Germany is the main export destination of Norwegian natural gas. All citizens have accessibility to electricity since 1990.

Norway, formally known as the Kingdom of Norway, is a country in the northern Europe. The country shares borders with Sweden in the east, Finland and Russia in the north east of the country. It has a long coastline in the south, west and north of the country to the North Sea and the North Atlantic Ocean. The country covers an area of 323.802 square kilometers and has a population more than 5 million people. Oslo is the capital city of the Norway (CIA, 2017).

Figure 50: Norway in the world map
source: http://www.countryreports.org/

According to BP data sets, hydro electric is forming more than half of the overall primary energy consumption of Norway. The other energy sources are responsible the rest. The country's hydro consumption was 32.4 Mtoe while total consumption was 48.6 at the end of 2016. Oil, natural gas, coal and renewables formed 16.1 Mtoe. Norway has 0.9 billion tonnes of oil, 1.8 trillion cubic meters natural gas proven reserves. According to International Hydropower Association (IHA), Norway has 31.6 GW installed capacity with approximately 1.4 MW pumped storage facilities.

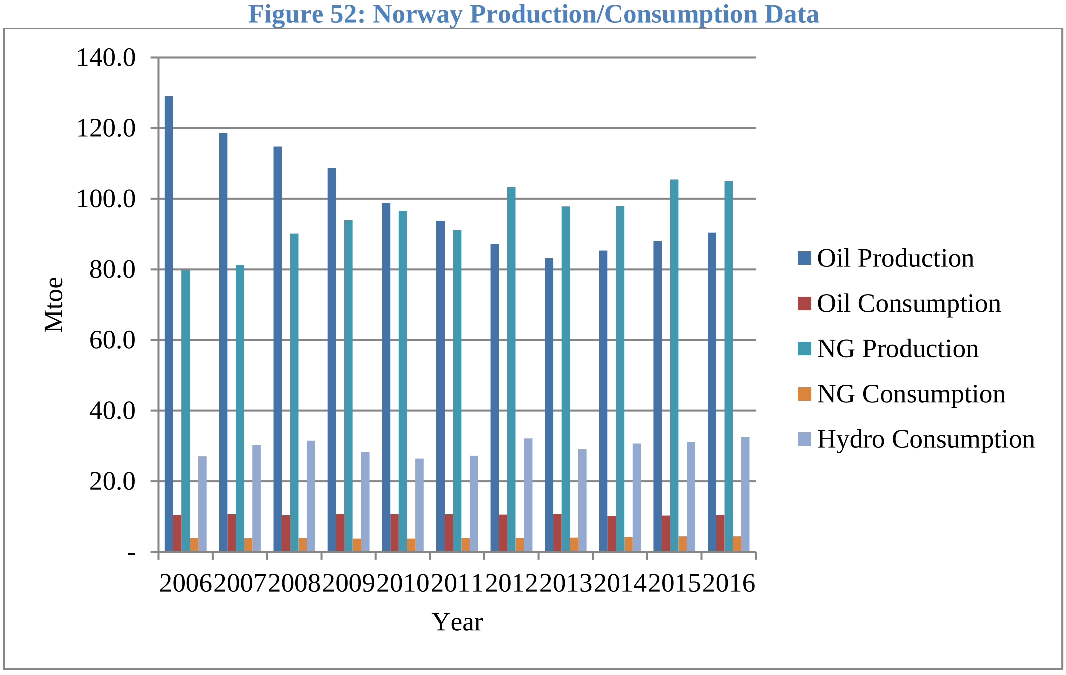
Figure 51: Norway Primary Energy Consumption by Fuel Types in 2016



Source: BP, 2017

The geographical features of the country are the main reason for high hydropower reserves. For instance, abundant natural lakes and fjords are the most important features. Norway produced 144 TW/hours electricity from its hydro sources and that was the highest in 2016. As a result of this rich hydropower sources and its effect to countries energy profile, Norwegian companies also exporting technologies (BP, 2017; IHA, 2017).

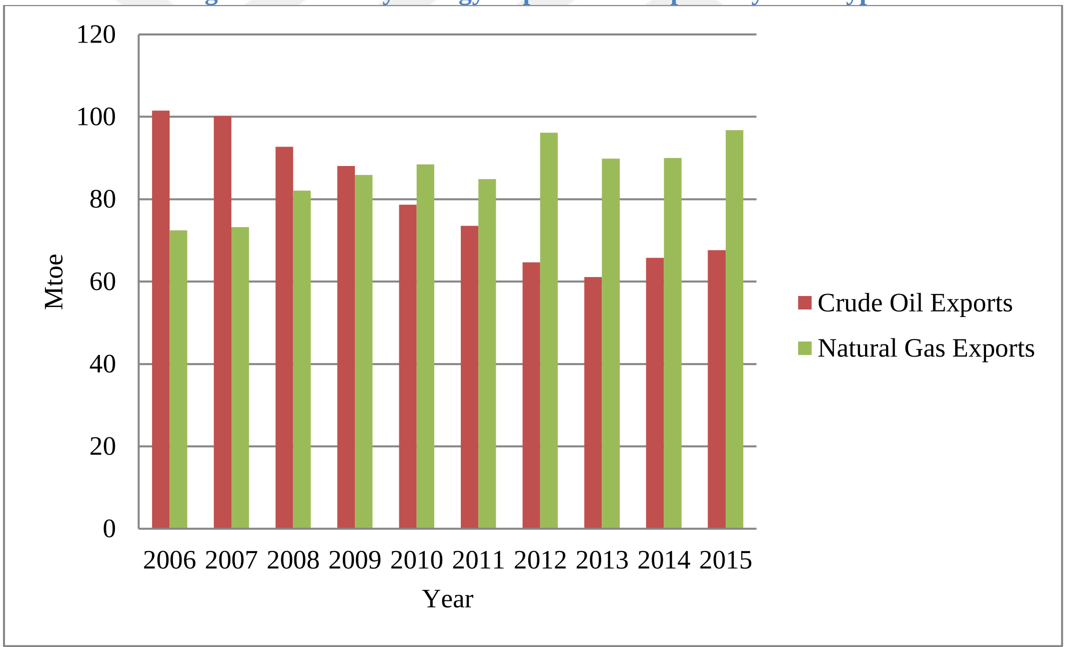
Figure 52: Norway Production/Consumption Data



Source: BP, 2017

Norway is the largest hydropower producer in the Europe and sixth in the world. According to IEA, the country is seventh highest producer and the biggest net exporter of natural gas in the world. In the figure 51, it is exhibited that obviously the country kept in balance its all consumption amounts with small and yearly fluctuations. There is an important transition year for Norway. Up until to 2012, crude oil production was always higher than natural gas. Although total production amount was higher it was steadily decreasing, simultaneously continuously increase on natural gas production. The first year was 2012, that natural gas surpassed the overall crude oil production and continued to increase. Since 2006, total production of oil decreased approximately 30% and fall 90.4 Mtoe at the end of 2016. In the same period of time, natural gas increased almost similar percentage amount and reached to 105 Mtoe. Norway had tried to keep in balance and not decrease or increase the overall consumption amounts for all energy sources (BP, 2017).

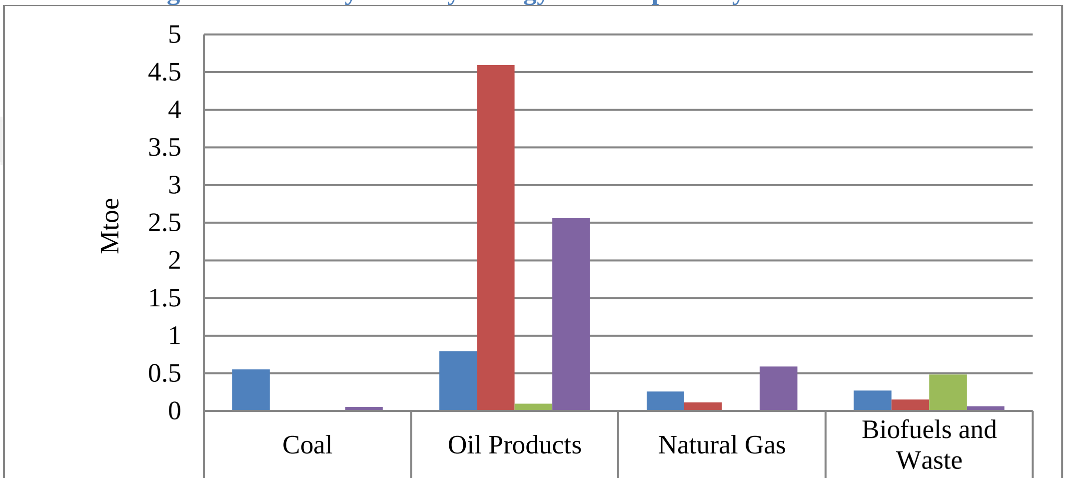
Figure 53: Norway Energy Exports and Imports by Fuel Type



Source: IEA, 2018

Norway highly utilizes crude oil and natural gas reserves, which are main export assets for the country. According to IEA, the country exports most of the crude oil to United Kingdom (UK) which was 69.3 Mt and natural gas to Germany which was 114.6 bcm at the end of 2016. Also most of the crude oil products were exported to Netherlands and small amount of coal to Germany. Norway is a one of the member of Nord Pool, which is an open electricity market in between Nordic countries. Sweden, Denmark, Finland, Iceland are the main members and Estonia, Latvia, Lithuania and Russia are the neighbors to this electricity generation and trade movement. Norway mostly imports and exports electricity from/to Sweden. Similar to production transition from crude oil to natural gas, country applied it to also main exports. It was 2012 for transition in the country but natural gas exports remained the increase since 2006 and surpassed crude oil in 2010 and never changed again. More or less parallel amount of decline and rise applied to exports, which was around 30% for production (IEA, 2018).

Figure 54: Norway Primary Energy Consumption by Sectors in 2016

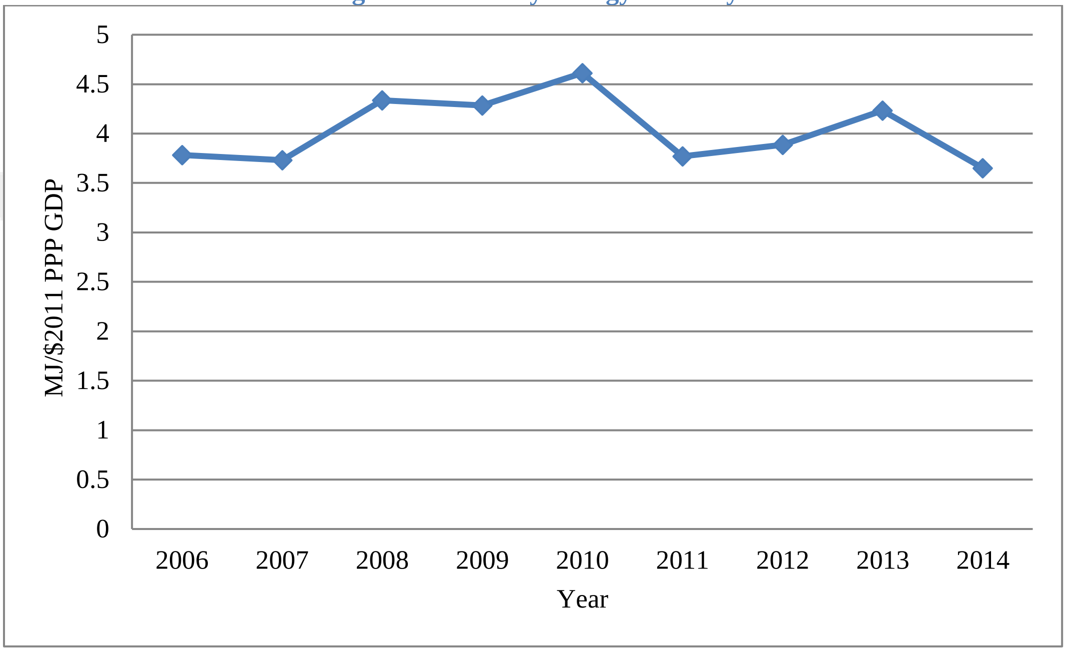


	Coal	Oil Products	Natural Gas	Biofuels and Waste
Industry	0.552	0.794	0.257	0.269
Transport		4.595	0.115	0.15
Residential		0.097	0.003	0.484
Other	0.055	2.561	0.591	0.06

Source: IEA, 2018

According to IEA's sectoral analysis of energy consumption, for Norway in particular, the other category consists of commercial and public services, agriculture/forestry, fishing, non-energy use and non-specified are sub-sections. The transportation sector was the leading among the four, with 4.86 Mtoe. Oil products were the main supplier of this sector (with almost 95% of total consumption), biofuels and waste, natural gas have negligible effect to the sector. Other was the second highest sector with a total amount around 3.2 Mtoe. This sector utilized four different energy sources in total and oil products had the largest among them. Furthermore, natural gas was mostly utilized by other sector. Industry and residential sector consumed less than transportation and others. Industry's total consumption was 1.8 Mtoe which was three times more than residential. Oil products were leading energy source also for industry similar to transportation and other sectors. Residential consumed the highest biofuels and waste among the four sectors. Industry and other was most diversified sectors with utilizing all four energy sources meanwhile transportation and residential utilized three of four main. Norway sectors' total consumption was 10.5 Mtoe in 2016. Between 2011 and 2015, Norway's energy consumption maintained a distribution among the sectors relatively similar to that shown in Figure 52 (IEA, 2018).

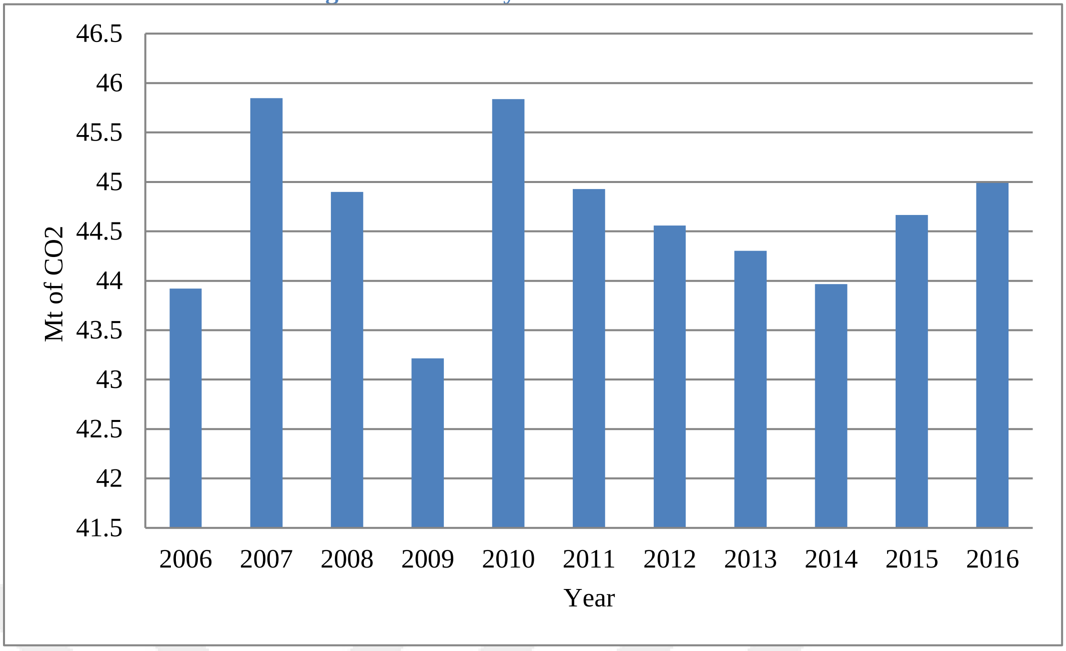
Figure 55: Norway Energy Intensity



Source: World Bank, 2017

According to WB data sets, the energy intensity level of primary energy (MJ/$2011 PPP GDP), for Norway was 3.6 MJ as at the end of 2014. The country intensity levels are steadily in a downtrend since 1990 with some small fluctuations. Simultaneously, country increased the overall production and consumption amounts. According to Institute for Energy Technology (IFE), the overall efficient use of energy, structural changes and, increased production, exportation rates and growth in the economy are the main reasons for Norway to keep its intensity level low, though there were some fluctuations in between 4.61 and 3.65 MJ in ten year period. The government targeted to decrease overall intensity rate by 30% up to 2030 (IEA, 2017; WB, 2017).

Figure 56: Norway Territorial Emissions

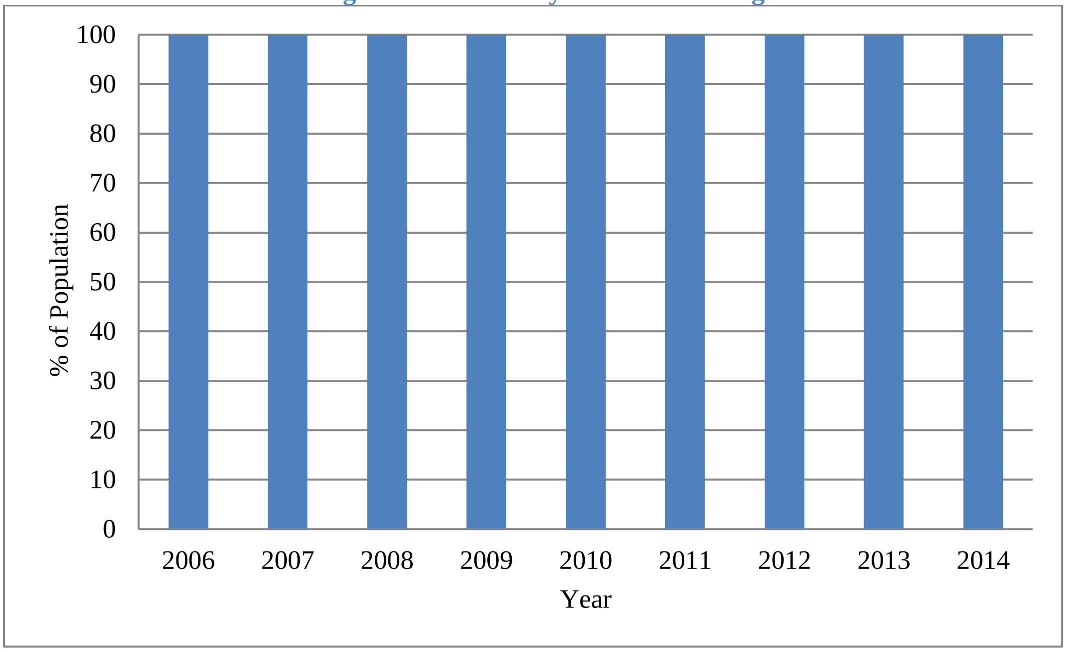


Source: www.globalcarbonatlas.org , 2018

According to Strategic Energy Technologies Information System (SETIS), Norway has two main energy strategies; Oil and Gas in the 21st Century (OG21) and Energi21. Both approaches target to utilize natural resources with high efficiency and in order to achieve it the country focused to improve technology up to current standards. These strategies underlined six priorities which are; solar cells, offshore wind power, utilization of resources using balance power, flexible energy system with smart grids and conversion of low-temperature heat to electricity, carbon capture and storage (CSS). Considering IEA report in 2017, Norway planned to decrease greenhouse gas emissions by 40% of 1990 levels up until to 2030. Current production facilities and buildings are almost totally carbon free in the country. Increasing the existing hydropower and CSS method are the primary solution which Norway applied.

The country created five new research and development methods as sub-implementations for OG21 and Energi21. The main aims of these five new R&D approaches to develop new solutions for both effective usages of natural resources and achieve low-carbon intensity. Clean Energy for the Future (RENERGI), planned to develop solutions for environment-friendly, economically efficient and effective management of the country’s energy resources, from 2004-2012 and after that follow-up program ENERGIX (Large-scale Program for Energy Research) adopted until to 2022. Especially for OG21, PETROMAKS 1 (Large-scale Program for Petroleum Research) established in 2004, in order to enhance fossil fuel reserves and usage in the country both research and industrial development. The program continued with PETROMAKS to between 2013 and 2022. For CSS application, Program for CO2 Capture from Power Generation and Other Industrial Sources (CLIMIT) was launched in 2005 and still ongoing, which covers the fossil fuel fired power plants (SETIS, 2017).

Figure 57: Electricity Access Percentage



Source: World Bank, 2017

According to WB data sets, Norway reached 100% electricity accessibility rates at the end of 1990. The country has a population of over 5 million people at the end of 2017. Since that year the accessibility rate have never changed in Norway. The population was 4.2 million people in 1990 and increased approximately 0.8 million in twenty-seven years. Industry is the leading sector that consumed approximately half of the electricity, followed by residential and commercial sector. The total generated electricity was approximately 150 TW/hours in 2016 (WB, 2017; BP, 2017; IEA, 2017). In the second half 2017, it was 0.16 Euro per kWh electricity prices for household consumers (taxes included) in Norway. Considering the information from Statistics Norway report, the total electricity bill charge are composed by 36% of taxes, 33% of electricity consumption and 31% share of the tariffs.

CHAPTER 7

7. FINDINGS AND CONCLUSION

This chapter will be demonstrating the response of determined research questions which are indicated in the methodology part of the study. As it mentioned in the previous chapters, this study focuses on energy security and its historical developments and the current situation in the four selected African countries, comparing them with selected benchmark countries. In the researches and as it capaciously analyzed in the literature review chapter, the energy security concept's origin is based to early 20th century. In the first decades, it was named as "security of supply" and mostly focused on the challenges which are coming from the supply side of energy flow. Afterward, energy security concept was enriched and expanded by the sectoral players due to steady developments both technological and social, in the world. Progressively, new perspectives and indicators added on the concept as branches of a tree. For instance, social, environmental, economical and physical perspectives enhanced the energy security. In general, 4A's concept became the focal point for the issue. Availability, accessibility, affordability and acceptability of energy considered as a beginning point to analyze energy security conditions in a country. Furthermore, another perspective underlined that, the current indicators are not sufficient enough to examine the situation and they added new three questions to concept, which are;

- Security for whom
- Security for which values
- Security from what threats.

This study examined more than hundred recent research in the literature and listed them in an excel table, to indicate what are the main indicators used by the studies done before. In figure 1 in the chapter 3, the results of excel list demonstrated. 35 different indicators utilized by authors for the scope of energy security. The top eight of them selected considering the current study of EC in 2010. The selected indicators are used to analyze selected countries' energy security situation of both African and benchmark. African countries and their energy security situations with selected indicators, which selected countries, are compared with example countries under the scope of benchmark analysis that is the main contribution of this thesis to form a guideline the African countries and study over rarely preferred subject.

1. **Where the selected African countries energy security positions are located in the world?**

In order to respond this question, this study considered the existing energy security analysis reports from different sources. For instance, Global Energy Institute's, International Index of Energy Security Index (2016) report, they focused on import/export balance, domestic usage, utilization of energy sources, energy intensity and sectoral usage. In addition, the selected indicators are parallel to this approach and have some other categories to analyze situations. The selected indicators are in table 1.

Considering all selected indicators, Algeria is far away from the diversification in the primary energy consumption in the country. The current situation is almost half of the consumption comes from natural gas and the other half from crude oil. The country utilizes its reserves highly both production and also exports. Beside high incomes from exports, the country has insignificant amount of imports of energy. Similar to overall consumption, sectoral diversification also is unbalanced. Country's energy intensity levels are in uptrend which is counted as a kind of challenge for energy security. Clearly, the existing energy policy, which is highly utilization of fossil fuels, the emission levels are also increasing. Algeria provides high accessibility to its citizen in affordable prices.

For Egypt, they are lacking of the diversification in energy sources. The country has good amount of reserves, it utilizes them both inside the country and exports but they are dependent to fossil fuels. Unlike its high export levels, the country imports negligible amounts of coal and crude oil. The dominance of natural gas and oil are also same in the sectoral usage of energy. Egypt's intensity levels are in downtrend since 2006. Even though, the vast usage of fossil fuels the country's emission levels are approximately 165 Mt from 2006 to 2016. Egypt is one of the most populous countries in the continent and they have achieved to provide 100% electricity access to its citizens, which is hard in Africa. Furthermore, country provides that access with affordable prices.

For Nigeria, dominance of fossil fuels easy to understand by primary energy consumption. Approximately %97 comes from both crude oil and natural gas supply. The country gains good amount of profits from oil exportations because Nigeria is one of the net producer of oil in the world. Country only imports the oil products which in actuality, they sell the crude oil and buy the products. Unlike the lack of diversification in general usage, biofuels and waste are one of the main sources for residential users in the country. According to IEA and sources, charcoal is counted as a type of biofuels and waste. In the Africa, Nigeria is the leading country which produces charcoal and firewood (AFREC, 2017). The country has high level of energy intensity but they are gradually decreasing it. Despite, high consumption amounts of fossil fuels; Nigeria has 95 Mt average emission levels. Electricity accessibility is something a challenge in the Africa. Many of the countries are below %50 of their population. Nigeria has almost a 190 million people of population and it provides electricity for %60 of them.

Lastly, South Africa has almost diversified energy consumption, although more than half of the supply comes from crude oil. They utilizes nuclear power and some renewable additionally to fossil fuels. The country is one of the net producers and exporters of coal in the world. Beside their exports, South Africa mainly imports crude oil and reflection this seen on the sectoral consumption. Transportation covers the most of the sectoral usage and oil products are the main source. Unlike having diversified energy consumption and utilizing nuclear and renewables the emissions level of country is high and in average it is around 460 Mt. The intensity level of country fluctuated between 8.8 MJ and 10 MJ and it is one of the highest in the Africa. The country provides electricity access around %85 which is way more than average.

According to analysis of countries in the scope of selected indicators, the main problem is diversification of energy sources. Dominance of fossil fuels needs to be under control by policies in all of four selected countries. This can be create an extra market in the countries and also can increase the exports. If they increase the diversification with utilization of other sources such as hydro and renewables their emission levels will also decrease. Only Nigeria and South Africa need to focus on enhancing existing infrastructures for accessibility to provide electricity to all their citizens. In the scope of Africa, they are the best representatives from their regions and overall in the continent. In the world scope, they could be in the average levels or somewhere near the average.

2. **What are the common and different points of the selected countries in between?**

The common points of selected African countries are; dominance of fossil fuels and each of them are net exports of one of the fossil fuels in their region or in the world. They have diversification deficit, all need to utilize renewables and hydro. They have great amount of reserves which can lead them to be self-sufficient if they organize their energy policies well. All are the leading countries with their deposits in their regions. All the selected countries are exporting good amount of energy and compared to their exports, import levels are negligible. As a result of using fossil fuels they are facing with high emission levels.

The different points; especially South Africa, the only country utilizes nuclear which is a good thing for their diversification and provides variety for the country. Algeria and Egypt provides sufficient electricity access to its citizens, even though Nigeria and South Africa are above the average of continent, they still need to be enhance their facilities and infrastructures to fulfill total demand. Electricity pricing also one of the different cases among the countries. Approximately, Algeria and Egypt serving electricity with affordable prices but for the others due to lack of accessibility it may be not sufficient for the citizens.

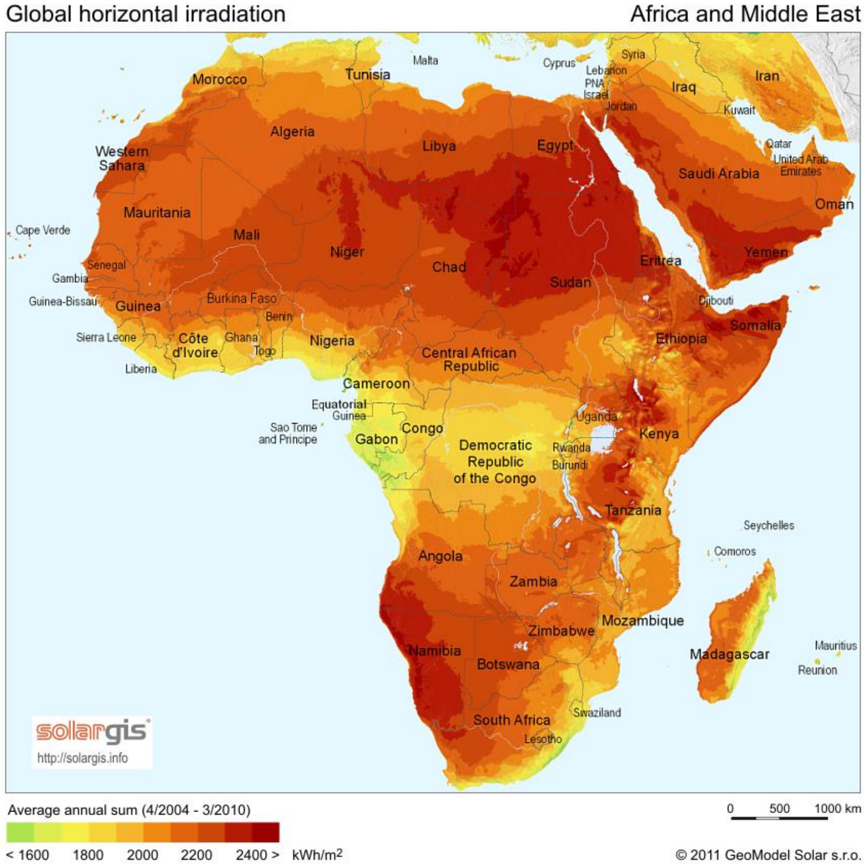
3. **What are the common and different points between African countries and benchmark countries?**

Benchmark countries are selected on purpose to be consistent with the indicators and African countries. Australia selected for coal, Kazakhstan for oil and Norway for natural gas which the each African countries are effective producers one of each energy sources. Despite the selection reason of benchmark countries, they are more various than African ones. Whilst, they are representative for one energy source they have also diversified primary energy consumption. Especially, Norway with more than half of the consumption comes from hydro meanwhile they have sufficient reserves of fossil fuels. All of the benchmark countries have %100 of electricity accessibility and high level of intention to increase renewables, decrease carbon dioxide emissions at the same time. The main difference is benchmark countries have effective policies to control their current situations and improve themselves.

In overall, African countries are mostly depended on fossil fuels, crude oil and natural gas are main energy sources for Algeria's primary energy consumption, where hydro electric and renewables have negligible impact. Egypt and Nigeria also depended on crude oil and natural gas, except South Africa, instead of natural gas coal and crude oil dependency on their primary energy consumption. On the other hand, Norway is leading country which their fossil fuel dependency is the lowest in between the benchmark countries with %32 – natural gas, coal and crude oil- . This dependency on fossil fuels also creates high carbon dioxide emission levels in the countries. Benchmarking countries have policies, agreements, studies and researches to decrease dependency and increase renewable energy usage for having more sustainable energy system in the country. This study suggests to African countries to increase renewable usage and decrease fossil fuel dependency both in order to utilize their resources in better conditions and reduce the emission levels in the country. For example, Kazakhstan's agreement with EBRD can be a good example for all four and other African countries to utilize their potential of renewables such as solar.

According to Solargis, Kazakhstan has 1750 kWh/m^2 which is approximately the minimum amount of Africa continent (Solargis, 2018). Evidently, there are more possible solar power for African countries which can be helpful to have more sustainable energy policy and less dependent on fossil fuels. Furthermore, if the countries decrease their own usage of fossil fuels that can lead them to increase/boost exports and gain more profits which can be an extra resource for country. In brief, even only one simple mentality change to decrease fossil fuels dependency and trying to increase renewables, especially solar power can influence the countries many other aspects as a butterfly effect in positive way.

Figure 58: African Irradiation Map



Source: Solargis, 2018

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APPENDICIES – A

An example electricity bill from Algeria – 25.03.2017

شركـة توزيـع الكهربـاء و الغـاز للوسـط
Société de Distribution de l'Electricité et du Gaz du Centre

Fourniture d'énergie Electricité et Gaz
BASSE TENSION / BASSE PRESSION

Capital social de 15000000000 de DA   Facture N° 448170302797   Etablie le 25.03.17

Direction Distribution TIZI OUZOU   Fax :

N°RC : 0805455B06   N°IS : 000609010536556   Dépannage Electricité : 026190202
N°RIP : 00799999000003806300ó   N°RIB : 00100581030030113941   Dépannage Gaz : 026190202
Agence commerciale : OUADHIAS   OUADHIAS CENTRE   Tél. : 026325269

CLIENT

Référence : 154513204670163   N°RC :   N°IS :
Nom et prénom : TOUMER SALEM BEN   Tél. :   Fax :
Adresse lieu de consommation : ALI AIT ABDELM
Nom et adresse du destinataire de facture :

Periode: 1er Trimestre 2017

CONSOMMATIONS
ELEC. PMD= 2 Kw
GAZ DMD= 5 m3h

Cle EBP: 225
Cle EBB: 817

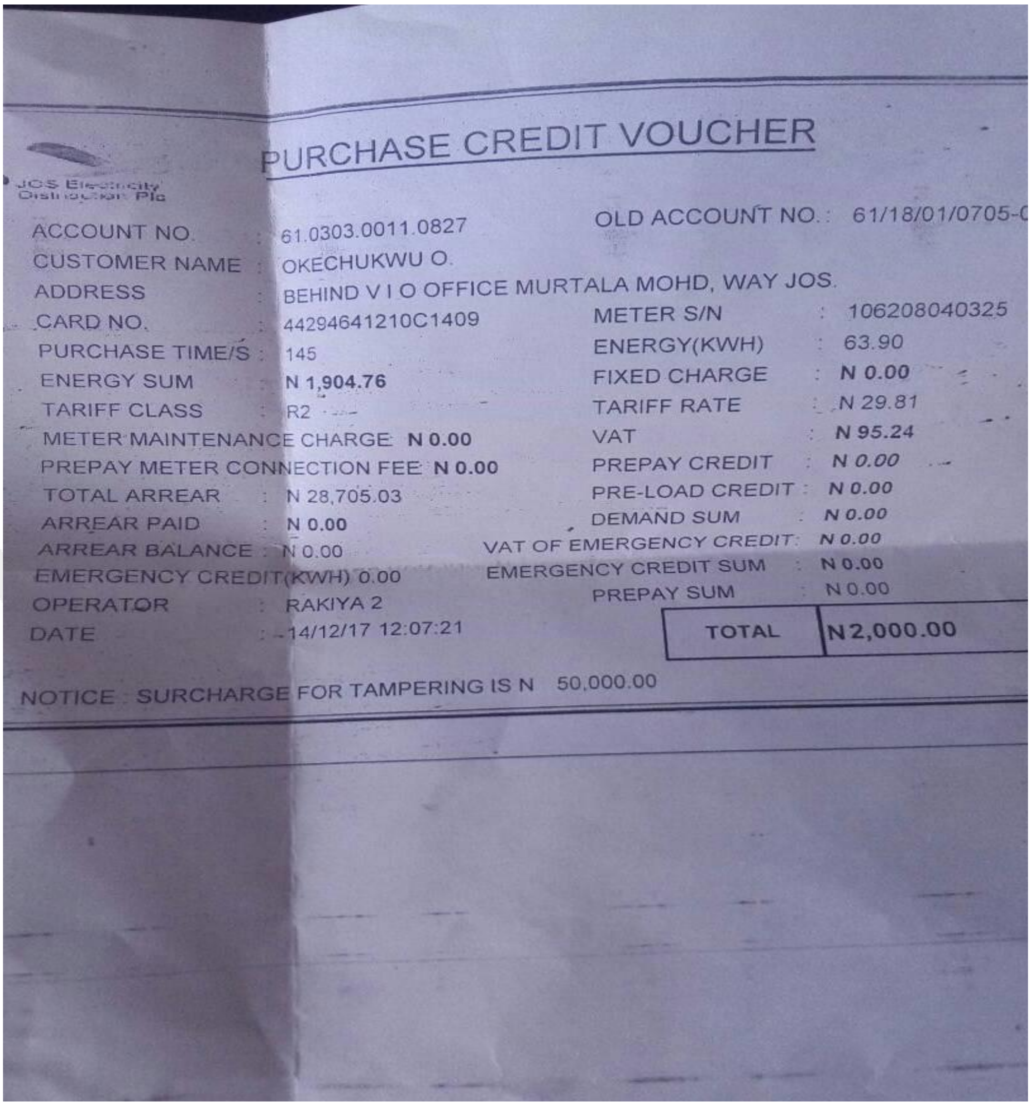
Tarif	N° Compteur	Relevé de compteur: Index nouveau		Index ancien		Différence	Coef.	Consommation (kWh/Th)
54 M	007760	[illegible]	R	[illegible]	R	340	1.00	340.00
23 M	274972	6947	R	5081	R	1866	9.70	18100.20

R:Releve E:Estime M:Releve Speciale

FACTURATION

Eléments	Tarif	N° Compteur	Tranches ou postes horaires	Consommation (kWh/Thermie)	Prix U (DA)	Montant HT (DA)	TVA Taux	TVA Montant (DA)	Montant TTC (DA)
ELECTRICITE	54 M	007760	Tranche 1	125.00	1.7787	744.70	07%	52.13	796.83
			Tranche 2	125.00	4.1789	433.08	17%	73.62	506.70
			Tranche 3	90.00	4.8120				
			Tranche 4						
PRIMES FIXES						52.44	07%	3.67	56.11
TOTAL ELECTRICITE(1)	54 M			340.00		1230.22		129.42	1359.64
GAZ	23 M	274972	Tranche 1	1125.00	0.1682	635.42	07%	44.48	679.90
			Tranche 2	1375.00	0.3245	6887.53	17%	1170.88	8058.41
			Tranche 3	5000.00	0.4025				
			Tranche 4	10600.20	0.4599				
PRIMES FIXES						85.50	07%	5.99	91.49
TOTAL GAZ(2)	23 M			18100.20		7608.45		1221.35	8829.80

An example electricity bill from Nigeria – 14.12.2017



JOS Electricity Distribution Plc

PURCHASE CREDIT VOUCHER

ACCOUNT NO. : 61.0303.0011.0827
CUSTOMER NAME : OKECHUKWU O.
ADDRESS : BEHIND V I O OFFICE MURTALA MOHD, WAY JOS.
CARD NO. : 44294641210C1409
PURCHASE TIME/S : 145
ENERGY SUM : N 1,904.76
TARIFF CLASS : R2
METER MAINTENANCE CHARGE N 0.00
PREPAY METER CONNECTION FEE N 0.00
TOTAL ARREAR : N 28,705.03
ARREAR PAID : N 0.00
ARREAR BALANCE : N 0.00
EMERGENCY CREDIT(KWH) 0.00
OPERATOR : RAKIYA 2
DATE : 14/12/17 12:07:21

OLD ACCOUNT NO. : 61/18/01/0705-0
METER S/N : 106208040325
ENERGY(KWH) : 63.90
FIXED CHARGE : N 0.00
TARIFF RATE : N 29.81
VAT : N 95.24
PREPAY CREDIT : N 0.00
PRE-LOAD CREDIT : N 0.00
DEMAND SUM : N 0.00
VAT OF EMERGENCY CREDIT : N 0.00
EMERGENCY CREDIT SUM : N 0.00
PREPAY SUM : N 0.00

TOTAL	N 2,000.00

NOTICE : SURCHARGE FOR TAMPERING IS N 50,000.00