KADİR HAS UNIVERSITY
SCHOOL OF GRADUATE STUDIES
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IMPORTANCE OF LNG IN TURKISH NATURAL GAS SUPPLY SECURITY

MEHMET BATUHAN ALKAN

ADVISOR: PROF.DR. VOLKAN Ş. EDİGER

COADVISOR: ASSOC. PROF.DR. GÖKHAN KİRKİL

MASTER'S THESIS

ISTANBUL, MARCH, 2019

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Submitted to the School of Graduate Studies of Kadir Has University in partial fulfillment of the requirements for the degree of Master’s in the Discipline Area of Engineering under the Program of Energy and Sustainable Development

ISTANBUL, MARCH, 2019

I, Mehmet Batuhan Alkan;

Hereby declare that this Master's Thesis is my own original work and that due references have been appropriately provided on all supporting literature and resources.

MEHMET BATUHAN ALKAN

22.03.2019

ACCEPTANCE AND APPROVAL

This work entitled **IMPORTANCE OF LNG IN TURKISH NATURAL GAS SUPPLY SECURITY** prepared by **MEHMET BATUHAN ALKAN** has been judged to be successful at the defense exam held on **25/03/2019** and accepted by our jury as **MASTER'S THESIS**.

Prof.Dr. Volkan Ş. Ediger (Advisor)	Kadir Has University
Assoc.Prof.Dr. Gökhan Kirkil (Coadvisor)	Kadir Has University
Asst.Prof.Dr. Filiz Katman	Istanbul Aydın University
Asst.Prof.Dr. Emre Çelebi	Kadir Has University

I certify that the above signatures belong to the faculty members named above.

Prof. Dr. Sinem AKGÜL AÇIKMEŞE
Dean

School of Graduate Studies

Date of Approval

25.03.2019

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LIST OF ABBREVIATIONS

°C – degree centigrade

ATM – atmospheric pressure

bar – a unit of pressure

Bcm – billion cubic meters

BOTAS – Petroleum Pipeline Company of Turkey *“ Boru Hatları ile Petrol Taşıma A.Ş”*

BTE – Baku-Tbilisi-Erzurum

Capex – capital expenditure

CH_4 – methane

CIF – cost, insurance and freight

CIS - Commonwealth of Independent States

CNG – compressed natural gas

CO_2 – Carbon dioxide

DEPA – Public Gas Cooperation of Greece

EEZ – Exclusive Economic Zone

EMRA – Energy Market Regulation Authority

EXIST – Turkish Energy Exchange *“Eneji Piyasaları İşletme A.Ş”*

FLNG – floating liquefied natural gas

FPSO – floating production storage offloading vessel

FSRU – floating storage and regasification unit

GHG – greenhouse gas

GTS – Gasunie Transporter Service

IGU – International Gas Union

IMO – International Maritime Organization

inch – British measurement unit 2.54 centimeters

ITG - Turkey-Greece Natural Gas Interconnection

JCC - Japan Crude Cocktail

JKM – Japan Korea Marker

Km – kilometer

kt/a - kiloton per annum

LNG – liquefied natural gas

LPG – liquid petroleum gas

LTC – long-term contract

MENR – Ministry of Energy and Natural Resources

MEPC - Marine Environment Protection Committee

mmcm - million cubic meter

MJ/L – mega joule / liter

mt – metric tons

Mtoe- million tons of oil equivalent

MTP – methanol-to-propylene

MW- mega watt

NBP – National Balancing Point

Opex - operating expenditure

PP – polypropylene

R/P- reserve/production ratio

TANAP – Trans-Anatolian gas pipeline

tcm – Trillion Cubic Meter

TTF- title transfer facilities

USSR – Soviet Union

WNA – World Nuclear Association

WTI – West Texas Intermediate

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ABSTRACT

ALKAN, MEHMET BATUHAN. IMPORTANCE OF LNG IN TURKISH NATURAL GAS SUPPLY SECURITY, MASTER'S THESIS, ISTANBUL, 2019

The Natural Gas has been increasing its share of usage day by day due to the technologic developments, low carbon emission, increasing natural gas reserve in the fossil-based energy market. Nowadays, the share of natural gas in the total energy mix is 24%. Hence, the natural gas has been seen as a transaction source because the countries are in the aim of zero carbon emission.

LNG is the most increasing product in the natural gas market these days due to shale gas production areas is far away to consumption areas according to this LNG usage has increased. LNG has been increased usage areas of natural gas and secure countries natural gas supply with regard to flexible system integration, easy transportation, and small scale cargos like oil products.

Furthermore, LNG is an essential value for Turkish natural gas market. In this study, the importance of LNG in Turkish natural gas supply security has examined. First of all, world natural gas and LNG market have analyzed, and developments and changes on the market have reviewed. Following to this, the Turkish natural gas market has been analyzed and business opportunities which LNG may make and advantages to the market have searched. In the mathematical model, future natural gas consumption, a share of LNG and pipe gas has been forecasted with three different scenarios. According to these forecasts, the determination has made with regard to the storage investments and what has to be done. Finally, what LNG is going to gain to the Turkish market and the importance of LNG in the Turkish natural gas supply is underlined.

Keywords: LNG, Natural Gas, Supply Security, importance of LNG,

ÖZET

ALKAN, MEHMET BATUHAN. LNG'NİN TÜRKİYE DOĞALGAZ ARZ GÜVENLİĞİNDEKİ ÖNEMİ, YÜKSEK LİSANS TEZİ, ISTANBUL, 2019

Fosil yakıtların egemen olduğu enerji piyasasında, doğalgaz, karbon salımınının düşük olması, gelişen teknolojiler ve artan doğalgaz kaynaklarına bağlı olarak dünya enerji piyasasındaki %24 olan pazar payını gün geçtikçe arttırmıştır. Bunun yanında ülkeler 0 karbon salınımı yolunda ilerlerken doğalgazı bir geçiş ürünü olarak görmektedir.

Günümüzde doğalgaz pazarında kullanım payını en hızlı arttıran ürün LNG'dir. Shale gas üretimi ile kaynakların kullanım alanlarından uzaklaşması LNG ye olan talebi arttırmışıtr. LNG hızlı sisteme entegre edilebilmesi, taşımacılıkta yarattığı kolaylıklar ve küçük kapasiteyle petrol ürünleri gibi ticaretinin yapıldığı göz önünde bulundurulduğunda hem doğalgazın kullanım alanını arttırmakta hemde arz güvenliğini sağlama konusunda ülkelere imkan sağlamaktadır.

Tüm dünyada olduğu gibi LNG Türkiye içinde değer kazanan bir kaynak olarak gözükmektedir. Bu çalışmada LNG'nin Türkiye doğalgaz arz güvenliğindeki önemi incelenmektedir.Çalışmada ilk olarak dünya doğalgaz ve LNG piyasası incelenerek piyasadaki gelişmeler ve değişimler gözlemlenmiştir. Daha sonrasında Türkiyenin doğalgaz pazarı analiz edilmiş LNG'nin yaratacağı iş imkanları ve markete sağlayacağı faydalar araştırılmıştır. Matematik modellemede ise gelecek yılların tüketimleri, LNG ve boruhattı gazının payları hakkında 3 seneryo çalışılmış ve buna bağlı yapılması gerken depolama yatırmları hakkında tespitler yapılmıştır.Sonuç olarak projede LNG'nin Türkiye marketine kazandıracakları ve Türkiye doğalgaz arz güvenliğinde ne düzeyde önemli olucağı vurgulanmıştır.

Anahtar Kelimeler: LNG, Doğalgaz, Arz Güvenliği, LNG'nin Önemi

INTRODUCTION

Compared to petroleum, natural gas has not been a fundamental part of the global energy system for nearly as long. Since the start is production of oil with modern drilling wells 1840s, oil has become increasingly prevalent in our daily lives. The invention of internal combustion engine, more than any other development, made petroleum essential in the transportation sector. Moreover, as a result of industrial and technological developments, petroleum products were used in various areas such as heating, lighting, and plastic production, all of which provide petroleum a prominent place in our daily life. In comparison to petroleum, which has a more common use, natural gas requires higher technology in order to produce, transport, and store. Thus, the efficient usage of natural gas was not initiated until the 1970s and technology was developed over the preceding decades. In addition, the continuous increase in population density around the world had caused an increase in energy consumption. Between 2008 and 2017, world energy consumption increased by 15% (BP, 2018) and this increase is expected to continue consistently in the forthcoming years. Consequently, the utilization of alternative energy resources is diversifying gradually and, while the search for more alternative energy resources continues, nowadays, energy resources are expected not only to meet the needs but also to be environmentally sustainable. In this context, natural gas is known to be the most environment-friendly fossil fuel, and its usage is increasing day by day.

In accordance with the increasing trade capacity, natural gas supply has become more significant. Natural gas is procured most efficiently via pipeline or tanker as liquefied natural gas (LNG). In total trade volume, LNG has a share of 35%. One of the main reasons for the increase in LNG trade is the discovery of U.S. shale gas. After this discovery, the ban on U.S. oil exports, established in 1975, was rescinded in 2015, after 40 years. In adidtion, the development of new liquefaction technologies in the LNG business has contributed to the growth of worldwide LNG supplies. LNG's most significant advantage is that it may be traded in small volumes just like petroleum products, which facilitates the distribution of gas by pipelines within countries. Hence, LNG seems to be the most attractive source for countries that are not able to build pipelines for geographical reasons or to cover the cost of consumption from external pipelines.

The main research question of this thesis is "What is importance of LNG in Turkish natural gas supply security? " This thesis will try to answer other questions regarding the potential effects of LNG on the Turkish natural gas market, how it will change after shale gas revolution, and what kind of business will be generated in accordance with these changes in the market.

First of all, I will define natural gas, world LNG and natural gas markets, proved reserve, total production and consumption and LNG, usage areas, the value chain of LNG (Liquefaction, Storage, Transportation, Regasification and Transmission) and world LNG import and export. The natural gas market is growing rapidly, and LNG production, gasification, storage, and ship transportation investments have also increased rapidly in recent years. With the growth in capacity, physical transfers in the international market are also becoming more numerous. Accordingly, the number of liquid enterprises is increasing, and the pricing mechanism becomes more transparent each day. The decrease in LNG prices depends on petroleum and the expansion of LNG's usage area will increase LNG trade. Pricing is another important issue in the market; therefore, the first part of the thesis also aims to explain the pricing mechanisms of some natural gas hubs. In this part, the most crucial topics are the shale gas revolution and a potential price war between Russia and the United States.

Second, I will look at the situation in Turkey. I will start with the historical background of Turkey's natural gas market and go on to explain its energy sources, actual natural gas market production, import figures, seasonal demand, usage areas, BOTAS's monopoly on the market, actual and potential natural gas sources, and Turkish natural gas dependency on supplier countries. Turkey's energy needs are increasing considerably faster compared to other countries in the same category. Natural gas is among the top three energy sources consumed in Turkey and its usage areas are diversifying daily. Currently, it is widely used in sectors such as household, conversion, electrical, transportation and industry. In 2017, annual natural gas consumption exceeded 16%, and annual consumption was 53.8 bcm (EMRA, 2017). Turkey's LNG imports from Algeria and Nigeria that are part of long-term contracts are also increasing, alongside its imports from the spot market. At the end of this part, it will also explain possible business opportunities for Turkey, such as how LNG could serve as feedstock for chemical plants, how it may be used in bunkering according to the International Maritime Organization (IMO) 2020 limitation rules and how LNG can be exported with road tankers to under-developed countries, which do not have enough pipeline infrastructure.

Thirdly, the thesis will analyze the Turkish natural gas market and storage capacities and provide forecasts regarding future consumption as well as the percentage of LNG in the market and explain the base case scenario. Based on these scenarios, we will estimate storage capacities and will prepare a projection about required investments.

The main object of this study is the Turkish energy market and the importance of LNG for Turkish energy-supply security. The purpose of this study is to analyze the world natural gas market, especially proved reserves, production and consumption, the shale gas revolution, and potential effects of shale gas on the natural gas market. Pertaining to shale gas' effects, this study focus on LNG. It will explain how the changing global market will affect the Turkish natural gas market and try to answer the following questions: "Why are energy source security and supply important?" and "What will change with LNG in Turkey?"

The U.S. shale gas revolution is a milestone for natural gas market, and LNG is the most feasible way to export this gas to other countries. In order to understand the importance of LNG, it is crucial to analyze historical background by looking at related data, reports and literature. While generating this thesis, all available reports, governmental and international web sites, official documents, academic journals, book and some reliable newspapers were consulted. Also, in this study, the estimates have been made regarding the future of Turkey by examining the data and comparing it with foreign markets.

In the literature review, previous studies were analyzed, and some related studies about LNG, Turkish natural gas supply security and Turkish natural gas dependency were considered.

However, the LNG business has only become important in Turkey after 2016. For this reason, there are few studies directly related to it.

Previous studies generally are related to the U.S. natural gas production and its increasing share of the LNG market (Corbeau and Yermakov,2016; Widdershoven, 2017; Foss, 2012; Ledesma, 2011; Ellio and Reale, 2017; Martin, 2017; and Bros, 2017). All agree that the shale gas revolution will increase global supplies of LNG. Also the International Gas Union and McKinsey published reports about increasing LNG capacity and usage. Corbeau and Yermakov, (2016) are focused on the possible price war, and Ellio and Reale, (2017) analyze the market share of U.S. LNG and Russian pipeline gas in the European natural gas market.

According to Corbeau and Yermakov (2016), increasing U.S. LNG in the European market threatens Russian market share. Russia has an advantage as a low-cost producer and if Russia decreases the prices, it can outcompete U.S. LNG. Another factor is the pricing model. U.S. LNG prices are based on gas-to-gas price and are more transparent; on the other hand, Russian prices are oil-linked prices and more complicated.

According to Ledesma (2011) and Victoria (2015), new technologies and floating terminals are increasing global trade of LNG, and small-scale cargos create accessibility to natural gas for non-developed countries or where pipeline have difficulty reaching for geographic reasons.

On Turkey's side, researchers agree that Turkey imports more than 99% of its natural gas needs and should secure natural gas supplies (Berk and Ediger 2018, Widdershoven 2017, Rzayeva 2014 and 2018, Ozturk, Yuksel and Ozek 2011).

Berk and Ediger (2018) analyze Turkey's vulnerability index. Turkey is a net importer in natural gas, and supply security is highly important because 31% of its energy mix is provided by natural gas. Also, Russia is the main supplier, providing 53% of Turkey's consumption. According to this information, Turkey's natural gas import vulnerability index is increasing exponentially, and the country should decrease it and secure supply.

LNG usage increased in Turkey after FSRU investments and the Marmara Ereğli LNG terminal expedition project (Widdershoven, 2017; Rzayeva, 2018). Widdershoven (2017) analyzes Turkey’s potential as an energy hub, for which Turkey is well positioned. However, only pipeline gas is not enough for Turkey to become a hub. The total number of sources should be increased along with LNG storage capacity and trade.

Rzayeva (2018) says that additional LNG is quickly and flexibly available to Turkey. In 2021, Turkey’s regasification capacity nearly doubled, and terminals stored more LNG thanks to the expansion of capacity. However, LNG prices are 20% to 25% higher than for pipeline gas, and Turkey should buy cheaper LNG in the market for sustainable business.

The first chapter of this thesis consists of the introduction, statement, purpose, methodology, and literature review. The second chapter looks at the following, what is natural gas and LNG?, the history of LNG, the value chain of LNG, pipe gas and LNG pricing mechanisms, the US shale gas revolution, and the price war between pipeline gas and LNG. The third chapter explains the Turkish natural gas market both today and in the past, state-owned BOTAS’s monopoly, and the actual and potential sources of natural gas for Turkey. A mathematical model is then put forth in the fourth chapter to analyze Turkey’s storage capacity under three different scenarios. The fifth chapter consists of a conclusion as well as recommendations about the importance of LNG in Turkey’s natural gas-supply security.

CHAPTER 1

WORLD'S NATURAL GAS MARKET

There are many different types of energy, and energy can be found in many places and take on many forms. Energy sources can be categorized as a renewable and nonrenewable. The primary energy sources for human development and economy are constantly changing according to technological developments. In the 1860s, the primary sources were wood and coal. However, today's primary energy source is oil. At the same time, the consumption of natural gas has been increasing since the 2000s. Oil is already a major energy source, but countries are sensitive about climate change and try to reduce their carbon footprints by focusing on increasing their use of renewable sources. Despite these efforts, renewable sources cannot alone meet global demand. This brings countries to natural gas, which is useful during this transition period because its carbon emission levels are 50% lower than oil. Natural gas may not be a definitive solution to fight climate change, but it is a remarkable transition source. Figure 1.1 explains the changes in oil and natural gas as a percentage of the world's total energy consumption. In 1965, the difference between oil and natural gas was around 30%; however, the difference between them is closing. Nowadays, the difference is around 10%.

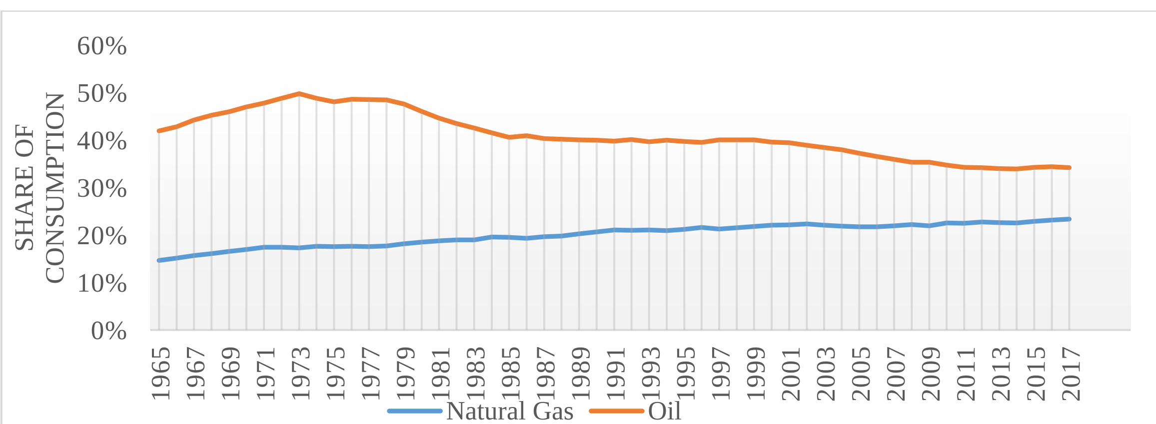


Figure 1.1: Percentage of Oil and Gas Consumption in World Energy Mix

Source: BP, 2018

1.1. OVERVIEW OF NATURAL GAS MARKETS

“Natural gas is one of the cleanest forms of fossil fuels, and its use is rising since the importance of environment-friendly conversion system has been seen” (Kanbur et al., 2017, p. 1171). It is a mixture of gases that are rich in hydrocarbons. It is primarily methane (CH4) with smaller quantities of other hydrocarbons such as nitrogen, carbon dioxide, etc. Natural gas was formed by the effect of high heat and pressure on mostly algae through millions of years under the earth. Natural gas moved into large cracks and spaces between layers in the rock. This type of gas is called conventional gas. Another type is found in the tiny pores, sandstone and other sedimentary rocks, and is called unconventional gas. Third type is associated natural gas, which occurs alongside crude oil. Natural gas is generally used for electricity generation for industries or households. It can also be compressed and used to fuel vehicles (CNG), and as a feedstock for fertilizers, hydrogen fuel cells and other chemical processes (IEA).

1.1.1. Natural Gas Proved Reserves in the World

The world total natural gas proved reserves are 193.5 tcm and more than 70% of it is located in the Middle East and CIS countries. The world reserves and production have a pozitif relation and reserve / production explain how many yeasrs of stock remains. There has always enough the world natural gas reserve for more than fifty years. In 2017, the reserves/production (R/P) ratio was 52.6, which means that the world has enough gas resources for the next 52.6 years. World consumption, however is increasing continuously, and the proved reserve capacity is increasing thanks to technological developments. Figure 1.2 shows the natural gas R/P ratio from 1980 to 2017.

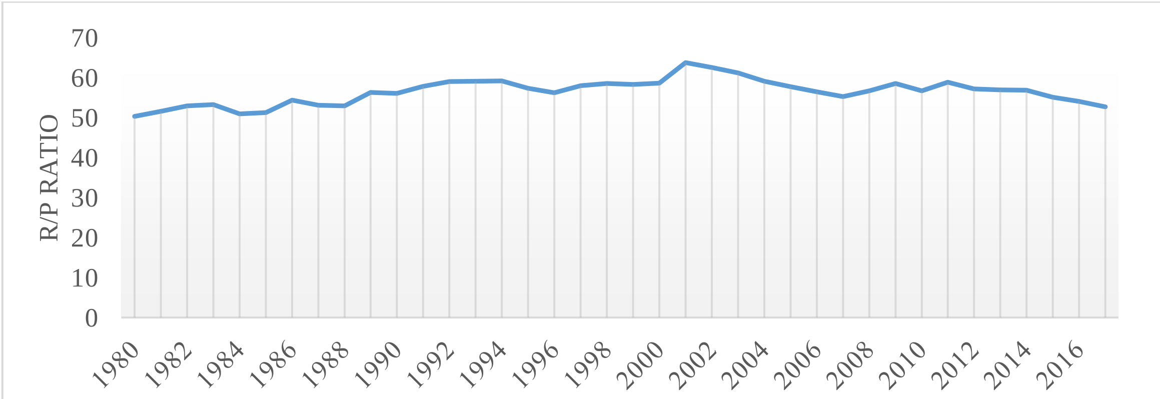


Figure 1.2: Natural Gas Global R/P Ratio

Source: BP , 2018

Table 1.1 shows the ten largest holders of natural gas reserve. It is noteworthy that the top four countries hold 58% of total reserves. After the shale gas revolution, US reserves have been increasing with new investments.

Table 1.1: Major Proved Reserve Holders

Countries	Proved Reserve (tcm)	Share%
Russian Federation	35.0	18%
Iran	33.2	17%
Qatar	24.9	13%
Turkmenistan	19.5	10%
US	8.7	5%
Saudi Arabia	8.0	4%
Venezuela	6.4	3%
United Arab Emirates	5.9	3%
China	5.5	3%
Nigeria	5.2	3%
Total	152.3	79%

Source: BP, 2018

1.1.2. Global Natural Gas Production and Consumption

In 2017, total world natural gas production was 3,680.4 bcm. The biggest largest gas producers are the United States, the Russian Federation, Iran, Canada, and Qatar. Their total production is 1.946 bcm, which is 52% of total world production (BP, 2018).

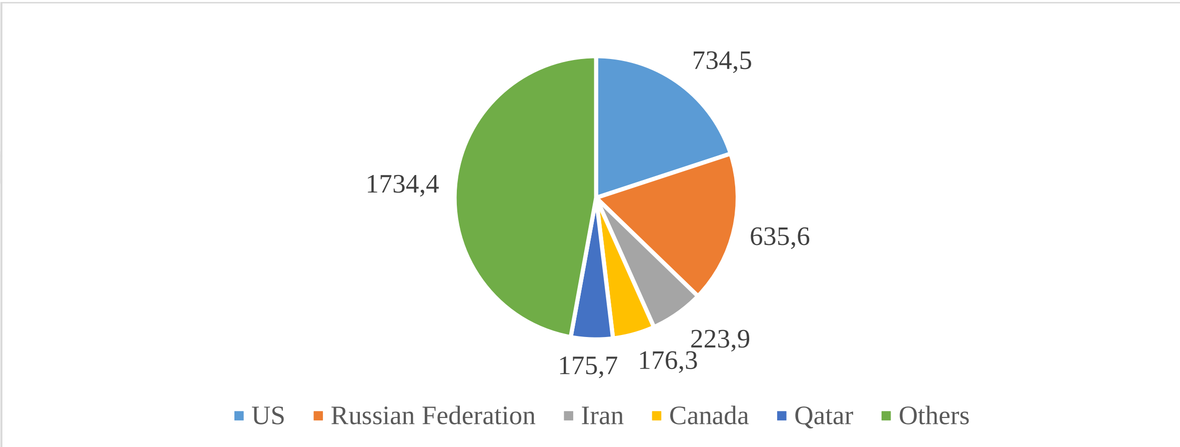


Figure 1.3: The World Natural Gas Production (bcm)

Source: BP, 2018

In 2017, total world consumption of natural gas has been 3.670.4 bcm. The five largest gas consumers are the United States, the Russian Federation, China, Iran, and Japan. Their total consumption is 1,736.2 bcm, which is 47% of total world consumption (BP, 2018).

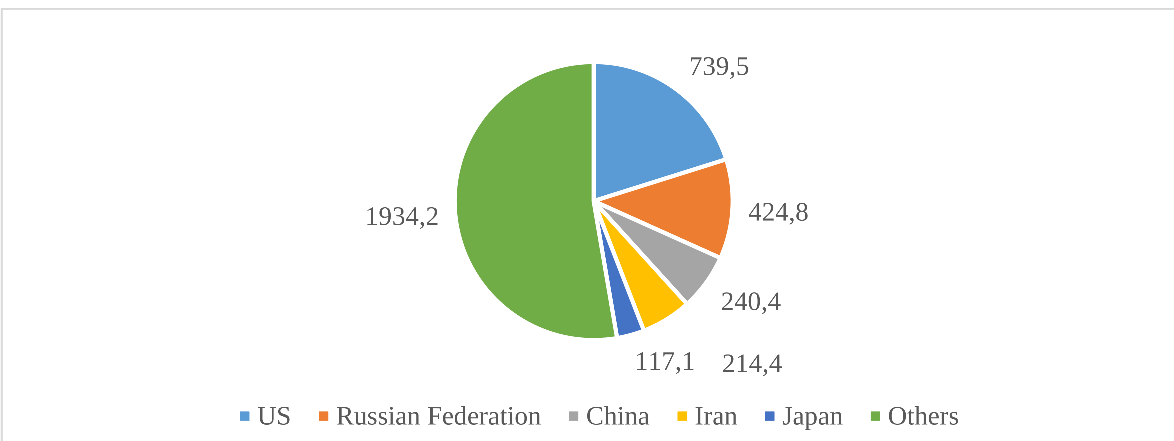


Figure 1.4: The World Natural Gas Consumption (bcm)

Source: BP, 2018

1.2. LNG

“The cryogenic liquid form of natural gas is called as LNG, which is obtained by the cooling of the natural gas to -162°C at the atmospheric pressure. It is non-toxic, odorless, colorless, safe, non-corrosive and the cleanest form of natural gas. LNG has almost no sulfur dioxide emissions and very low-level nitrogen emissions during the combustion step” (Kanbur et al, 2017, p.1172). Quality is another important issue, as LNG is purer than natural gas. LNG’s biggest advantage is transportation and security. It is a safer and more economical alternative for transportation and creates an advantage for storage capability. Transoceanic pipeline production is too expensive and often impossible due to technical limitations. However, after liquefaction, LNG can easily be transported around the world with special cryogenic vessels. LNG is not a new technology but one that has developed slowly and is continuing to develop.

The historical development of LNG dates to the nineteenth century. British chemist and physicist Michael Faraday was the first to explore liquefying natural gas. In 1873, German engineer Karl Von Linde studied refrigeration compression. After that, in 1917, the first LNG liquefaction terminal was built in eastern Virginia. The first usage was realized in Ohio in 1941 (S&P Global, 2016). Vessel transportation started in 1959. The first LNG vessel, the *Methane Pioneer*, carried LNG from Louisiana to England. Five years after this first export, England imported LNG from Algeria, making it the first LNG importer and Algeria the first LNG exporter (Foss, 2012). In the 2000s, the LNG trade started to increase because, the number of liquefaction terminals, regasification terminals, and LNG vessels also increased.. Also, vitally amount of LNG came on the market from QatarIn 1970s LNG trade was 6% of the total natural gas trade. However, in 2017 it was 34.5% of the total natural gas trade (BP, 2018).

The following table shows countries that do not consume natural gas, according to Oxford Energy Forum (Lambert, 2017). These potential countries represent markets for LNG producers. LNG consumption is expected to continue for many years. Increasing LNG trade is vital for countries that cannot transport natural gas via pipeline because of geographic hurdles or low GDP. Exporter countries need to invest in liquefaction terminals and cryogenic vessels in order to cultivate new markets. On the other hand, importer countries need to regasification terminals. It is essential for resource diversification because LNG creates essential advantages for importers. The reason for the increase of LNG trade is European and Asian countries increasing their demand.

Table 1.2: Countries without Natural Gas Consumption

1	North Korea	21	Sri Lanka	41	Haiti	61	St Lucia
2	Kiribati	22	Grenada Greenland	42	The Gambia	62	Sudan
3	Laos	23	Djibouti	43	Fiji	63	Somalia
4	Liberia	24	Uganda	44	Sao Tomé and Principe	64	Zambia
5	Mongolia	25	St Vincent	45	East Timor	65	Zimbabwe
6	Malawi	26	Dominica	46	Antigua and Barbuda	66	Nepal
7	Montenegro	27	Eritrea	47	Botswana	67	Nauru
8	Madagascar	28	Namibia	48	Belize	68	Suriname
9	Lesotho	29	Western Sahara	49	Benin	69	Nicaragua
10	Kenya	30	Samoa	50	Rwanda	70	Guinea-Bissau
11	Honduras	31	Swaziland	51	St Kitts and Nevis	71	Panama
12	Iceland	32	El Salvador	52	Falkland Islands	72	Paraguay
13	Mali	33	Ethiopia	53	Comoros	73	Vanuatu
14	Mauritius	34	Tonga	54	Cayman Islands		
15	Solomon Islands	35	Togo	55	Cape Verde		
16	Bhutan	36	Burkina Faso	56	Costa Rica		
17	Congo	37	Sierra Leone	57	Central African Republic		
18	Burundi	38	Mauritania Guatemala	58	New Caledonia Niger		
19	Cambodia	39	Guinea	59	Bahamas		
20	Chad	40	Guyana	60	Seychelles		

Source: CIA World Factbook,2016

At the same time, countries already importing LNG are increasing their imports. The highest demand is coming from Asia-Pacific countries. Since these countries are geographically far away from producer countries, they meet a significant portion of their energy requirements from LNG. In 2017, the total world trade in LNG was 393.4 bcm. Asia-Pacific countries imported 283.5 bcm, which was 70% of the global LNG trade. According to the McKinsey Global Gas and LNG Outlook to 2035, LNG importation to Asian countries will increase 12% year over year. If demand increases 1% every year until 2035 (McKinsey, 2018).

LNG is more expensive than coal and is dirtier than renewable sources. However, LNG is the cleanest fossil fuel. Currently, 85% of the world's consumption is provided by fossil fuels. The distribution is 34% from oil, 23.5% from natural gas, and 27.5% from coal. For that reason, increasing LNG demand is also important for reducing greenhouse gas emissions. LNG usage in the transport sector is increasing rapidly (Kumar et al., 2011). The following table shows a summary of the lifecycle GHG emissions of technologies. It illustrates the difference between gas and other fossil fuels. For a sustainable future, LNG can help the world transition to a cleaner energy regime.

Table 1.3: Lifecycle Greenhouse Gas Emissions of Technologies

	Mean	Low	High		Mean	Low	High
Technology	tons CO_2 e/GWH			Technology	tons CO_2 e/GWH		
Lignite	1054	790	1372	Biomass	45	10	101
Coal	888	756	1310	Nuclear	29	2	130
Oil	733	547	935	Hydroelectric	26	2	237
Natural Gas	499	362	891	Wind	26	6	124
Solar PV	85	13	731				

Source: WNA, 2011

1.3. VALUE CHAIN OF LNG

The value chain of LNG is more complex than natural gas. First, the natural gas produce in the reserve. Secondly, it is liquefied with a special technology, cooled to -162 °C, and stored in the cryogenic tanks. The LNG stored is ready to transport around the globe with special designed cryogenic tankers. Third, it can be stored in the consumer's tanks. Finally, LNG is regasified again and vaporized for the end market consumer.

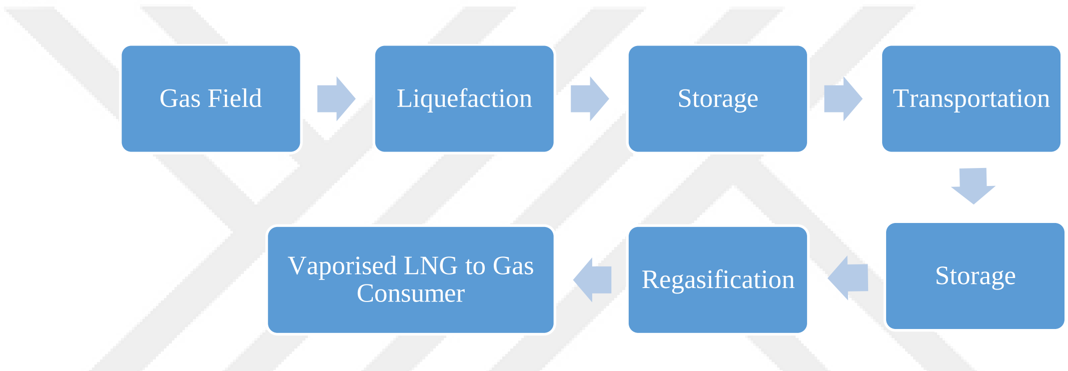


Figure 1.5: Value Chain of LNG

1.3.1. Liquefaction

In this process, gas enters the LNG exchanger, and it is cooled against the cold refrigerant stream to the required LNG storage conditions of lower than -155°C. The cold low-pressure refrigerant stream also acts to condense the high-pressure refrigerant stream prior to the pressure letdown stage that provides the necessary heat exchanger cold side temperature differential (Remeljej and Hoadly, 2006). The world nominal liquefaction capacity increased 29 mtpa from March 2017 to March 2018 to 369 mtpa, with 92 mtpa liquefaction santal under construction (IGU, 2018). Floating liquefied natural gas (FLNG) is a new technology for liquefaction terminals and is generally used for offshore gas reserves. The first FLNG project, Prelude, started operating in late 2016, and was built by Shell. It is located 200-km offshore of Western Australia and at a depth of 200-250 meters from the water. The project was designed to produce 3.6 million tons of LNG (Ledesma, 2011). During 2017, another FLNG plant, Coral South, started liquefaction in Mozambique. At end of March 2018, global proposed liquefaction capacity reached 875 mtpa, and the major countries are the United States and Canada. It shows that LNG market expanding quickly and will continue to do so in the coming years (IGU, 2018).

1.3.2. Storage:

Storage is significant for winter gas shortages period (peak shaving facilities meet the fluctuating seasonal demand for gas) (Kumar et al., 2011). LNG is generally stored in cryogenic tanks, which have pre-stressed concrete on the outside and a 9% nickel-steel inner tank to hold the LNG at -160 °C. LNG is stored in the tanks at atmospheric pressure (1 ATM). Cold insulation is provided between the outer and inner tanks to minimize heat ingress to the tank. “This would ensure that LNG can be stored in the tanks at low temperature with minimum vaporization of LNG.” (Kagaya et al., 2017). LNG can be stored in onshore tanks, floating production storage & offloading (FPSO) vessels, and floating storage units (FSU). The world receiving capacity was 851 mtpa in March 2018 and 87.7 mtpa of new capacity was under construction. Japan has 198 mtpa, the United States 129 mtpa, and South Korea 127 mtpa, and are the three largest countries. At the end of 2017, total storage capacity was 62.7 million cubic meter (mcm). The three countries with the highest storage capacity are Japan (17.4 mcm), South Korea (12.6 mcm), and China 7.1 (mcm) (IGU, 2018).

1.3.3. Transportation

LNG is transported with special LNG tankers over long distances. They have cryogenic storage tanks. At the end of 2017, 39 new tankers were built, and 478 tankers were active in the world market, with 27 of them are FSRU and three FSU. Tankers’ storage capacity is also rapidly growing, and new tankers have capacity around 170,000 cm. 106 new tankers will join the system before the end of 2020.

1.3.4. Regasification

LNG has cryogenic characteristics and must be re-gasified before it can be transported to end-users. Generally, the cold energy of LNG is absorbed by seawater during the regasification process (Lee et al., 2017). In practice, regasification is performed by gradually warming the gas back up to a temperature of over 0°C. It is done under high pressures of 60 to 100 bar, usually in a series of seawater-percolation heat exchangers, the most energy efficient technique when water of the right quality is available. Global regasification capacity is 875 mtpa (IGU, 2018). A floating regasification unit is a unique vessel capable of transporting, storing, and regasifying LNG on board. Global regasification capacity of FSRU is 84 mtpa. FSRU is the future of the regasification process and an essential part of LNG trade.

Two types of FSRU are being used in the market. The first one is converted by an LNG tanker; the second one is new production FSRUs. The conversation cost is based on the cost of the vessel plus roughly $80 million for the construction work; the construction period is 18 months. A new production vessel, on the other hand, is around $360 million and takes roughly 36 months to construct. Depending on the project's details, companies choose either to convert old vessels or build new ones (Songhurst, 2017). Both options, in any case, are faster and cheaper than onshore terminals and more flexible. It can be relocated according to seasonable demand, so it can be useful where the natural gas needed. Floating regasification offers a flexible, cost-effective solution for smaller or seasonal markets, and can be developed in less time than an onshore facility of comparable size (Zaretskaya, 2015).

1.3.5. Transmission

Two types of transmission are possible in the system. The first is to, after regasification, vaporize the LNG so that it can be sent through the transmission system. The other method is more prevalent. Stored LNG is cooled to -190 °C and then loaded on road trucks. LNG is loaded on to a truck without a pump using inside tank pressure, which decreases while the road truck tank pressure increases. Moreover, LNG is then regasified at its end point.

Generally, factories employ this system and build their storage tanks as well as an atmospheric evaporator for regasification (Yurtman, 2008).

1.4. WORLD LNG IMPORTS AND EXPORTS

The worldwide natural gas industry has great potential because new technologies can successfully convert gaseous methane to transportable LNG. In 1990, LNG accounted for 56 mt and 4% of global gas, and in 2004 it increased to 131 mt, 7% of global gas. In 2017, the total LNG capacity was 393.4 bcm. The largest importers were generally located in the Asia Pacific region. The world's largest importer was Japan, whose imports were 113.9 bcm in 2017, which translated to 28% of total world imports. The reason for this is that after the Fukushima nuclear leakage, Japan altered its energy policy to decommission nuclear, and LNG was needed urgently as a stopgap. Other major importers are South Korea, China, Spain, and the United Kingdom.

The largest exporter is Qatar, which sent 103.4 bcm of LNG abroad in 2017, which translated to 26% of global exports. Other major exporters are Australia, Indonesia, Algeria, and Trinidad Tobago. Also, the United States' exporting capacity is growing annually after the shale gas revolution. The country has been exporting this gas as LNG since 2016, when it sent 4.3 bcm to the global market. In 2017, exports totaled 17.4 bcm, which represented an increase of 404%.

Moreover, global authorities believe that the US will remain one of the top five exporters of LNG (BP, 2018). The global trade in LNG has a slightly increasing trend. Over the last ten years, the total share of LNG increased by 7%. Figure 1.6 below explains the total gas trade volume and percentage of LNG between 2006 to 2017.

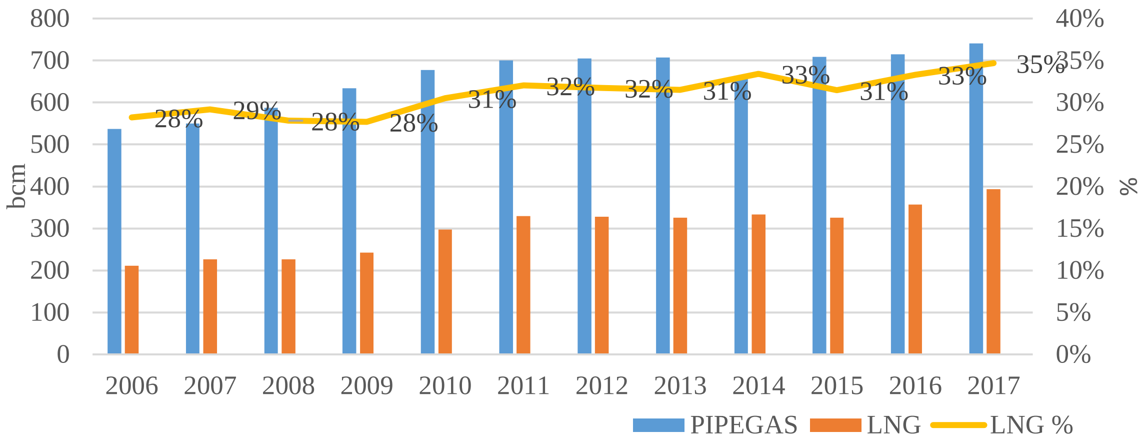


Figure 1.6: Trade Movements of Pipe gas and LNG between 2006 to 2017

Source: BP, 2018

Also, the following figure depicts the major trade movements of LNG in 2017. The figure clearly shows how easily LNG can be shipped globally. The LNG movements shown in blue lines are more numerous than the red ones, which show, pipeline deliveries. However, pipeline deliveries are carrying larger volume compared to sea deliveries. For this reason, LNG is the keystone of the natural gas spot market, and it is the best and quick solution for seasonal demand.

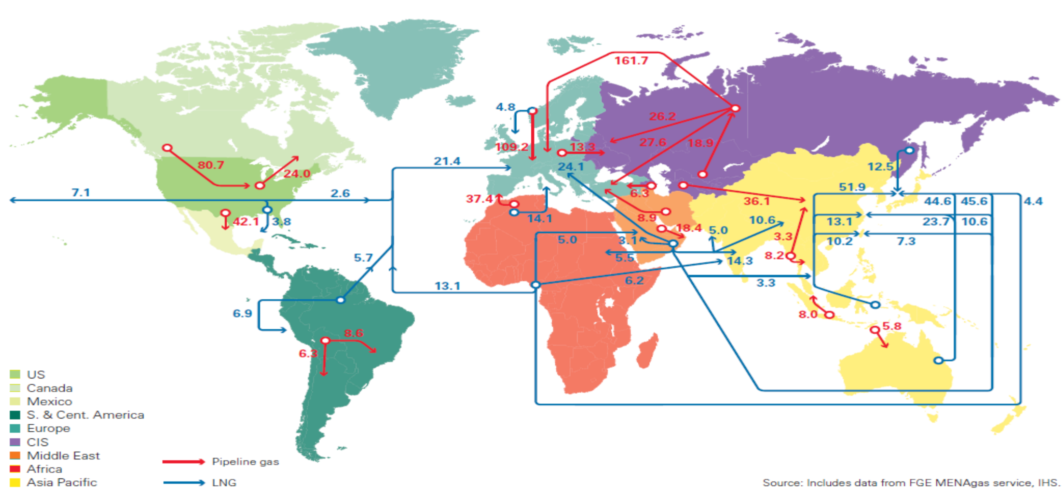


Figure 1.7: Major Trade Movements 2017

Source: BP, 2018

1.5. SHALE GAS REVOLUTION

Shale gas is a new type of unconventional natural gas resource that has attracted massive attention in the fields of oil and gas research and exploration in recent years. Shale gas is the natural gas extracted from shale beds and is characterized by its unique process of formation and enrichment distribution. It is mainly distributed in shale beds with relatively large thicknesses and broad distributions across sedimentary basins and is formed and reserved in dark rocks that are rich in carbonaceous matter. Shale gas can form at various stages of organic hydrocarbon generation. It exists mainly as a free state in fractures and pores, along with some adsorbed on the surfaces of kerogen, grains, or pores, with a minimal amount dissolved in the interstitial fluids (Wang, 2017).

Shale gas has been known to exist for several years from now on but producing gas from shale was not profitable due to lack of information and technology. There was only limited production, which was not attractive for gas producers. Before the revolution, producers used hydraulic fracking and horizontal drilling technologies separately. After 2006, these two existing technologies were combined and created a more profitable production process. These technologies will be explained below. Since 2000, the development of new exploration technology for shale gas led to a rapid increase in shale gas production in North America, as a consequence of which the shale gas revolution was ushered in early 2006 in the North American natural gas market (Geng et al. 2016).

1.5.1. Horizontal Drilling

Gas drilling is described as a process of drilling wells with gas containing air, nitrogen, and natural gas. It is an optimal technique for drilling horizontal wellbores in hard formations. Because of the low cuttings-carrying energy of gas in horizontal gas drilling, drill cuttings return to the surface in a dusk-like state, while the large cuttings cannot be circulated out of downhole in time and cannot be reground by the bit teeth, as is the case in vertical gas drilling. Consequently, they are easily saved in the horizontal wellbores, which may lead to accidents such as wellbore plugging and pipe sticking. Drilling horizontal wells for gas has recently been contemplated as a useful technique for shale gas reservoir development. It can improve footage capacity by almost 60% and decrease drilling costs (Bilgen and Sarıkaya, 2016).

1.5.2. Hydraulic Fracturing

Hydraulic fracturing is a technique used in oil and gas production to raise hydrocarbon recovery from low-permeability formations. During a hydraulic fracturing operation, fluid is injected into an oil and gas well at a high pressure—a process that fractures the rock of the hydrocarbon-bearing formation, thereby rising its hydraulic conductivity and the rate of the flow of oil and gas from the formation to the wellbore.

High levels of water and disposal of vast amounts of backflow fluids are significant requirements for hydraulic fracturing. A general shale gas well needs nearly 10,000-20,000 cubic meters of water. The requirement for water can be immense with a dense grid of wells and can have an unfavorable effect on the resources of surface and groundwater in the close area. The vertical part of a well in a hydraulic fracturing process is first drilled from the surface to the shale layer. Steel casing and cementing are needed for the conservation of freshwater aquifers and well stability after vertical drilling.

Horizontal drilling alone is not enough to induce sufficient natural flow from shale formations to the well for the extraction to be economically feasible because of the low permeability of shale. Therefore, hydraulic fracturing is necessary for the extraction of shale gas. Hydraulic fracturing is not unique for unconventional gas; it was previously applied in the oil and gas industry for decades to stimulate the hydrocarbon production of wells with decaying rates. This technique is also not continual: wells are fractured once after drilling and the procedure is carried out in stages. Later in the well's lifecycle, the operation can be repeated for re-stimulation, as the production declines. After horizontal drilling is finalized, a cement casing is created around the well, and then perforated with a special gun. After that, the fracking fluid is injected at a high pressure so that it can enter the formation through the perforations created earlier, and fracture the rock (Bilgen and Sarıkaya, 2016).

1.5.3. Pipe Gas or LNG (US and Russia energy price war)

The outcome of a price war between Russian pipeline gas and U.S. LNG is not unavoidable. That fight has been years in the making, with the growth of U.S. liquefied natural gas exports set to challenge established supplies of Russian pipeline gas yet the U.S-Russian competition for European gas markets continues to be genuinely embryonic, and thus cannot be predicted with high precision.

"Even in a scenario of low LNG supply and high Chinese demand, Russia's market share in Europe would still be slightly below 30%. The Russian strategists may first consider, whom they know would struggle to recover their costs, is not serious. However, in practice, this LNG will come to the markets nonetheless, as aggregators are already selling LNG at a loss. This could force Gazprom management to reconsider the company's previous policies. Russian gas, with its sunk upstream and transportation costs, continues to look attractive compared with U.S. Gulf Coast LNG on the basis either the variable cost of supply" (Corbeu and Yermakov, 2016, p.39).

"Whether oil prices are high or low, another important element for Russia is the level of U.S. gas prices" (Corbeu and Yermakov, 2016, p.40). Within the past years, the decline in oil prices and gas costs are additional or less synchronous, but these are different goods that have their own systems.

Europe is a market that Gazprom considers its area because it has been the dominant provider of European gas for several decades, with its monopoly on pipeline exports from Russia. According to authorities, over the last year, the United States has increased LNG supplies to Europe. However, it now has only 6% of European LNG imports, which does not take into account natural gas supplies through pipelines and, according to Gazprom, Russia had a 34% share of the European gas market last year.

At first look, Gazprom has a strong hand in the competition due to its home advantage, vast reserves, low production costs, and most importantly, its pipelines, which make its gas much cheaper than LNG, which has a more intricate and expense transit process. However, the arrival of the U.S. gas in Europe is now taking on a more overtly political edge. The flexibility and increased competition in the market may bring down prices for European customers. As a result, this may prove to be one U.S.-Russian battle where the winners are the end users in Europe.

In addition, we have considered the U.S.-Russia duopoly at length, in light of market dynamics and geopolitical tensions between those two countries. Significant changes in Europe in terms of prices and/or supply and demand balance would impact these two countries as well as their attendant geopolitical contest. While relations between Russia and Europe have become distant, cheap and productive, Russian gas could potentially help renovate commercial relations. Yet tensions between Russia and the United States have risen on account of the Ukraine situation, Syria, and U.S. commercial sanctions on Russia.

What is additional, the structure of European LNG markets is also undergoing a transformation. Up to now, LNG has been primarily viewed as a technique for long-distance transport of methane. Accordingly, natural gas is liquefied, shipped, then regasified and directed to pipeline networks, where it is further used in traditional industrial segments, such as electricity generation.

From an economic perspective, most U.S. LNG projects are set up to be competitive as import terminals are converted into export terminals, making use of existing infrastructure, so-called brownfield projects. This conversion means capital expenditure (CAPEX) and operating expenditure (OPEX) are units typically well lower compared to entirely new greenfield plants (jetty, storage tanks, pipeline infrastructure, etc.). These savings combined with low feed gas prices (discounted Henry Hub prices) should guarantee a stable, competitive position for U.S. LNG in the global market. However, comparing U.S. LNG with Russian pipeline gas is not comparing apples to apples. LNG is more complex than pipeline gas, making it more difficult to control and generally more expensive. Moreover, though within the EU there is a political interest in decreasing dependence on Russian gas, EU consumers will be much less fussy about Russian gas if they know that swapping it for U.S. LNG will result in an increase in price.

Nevertheless, U.S. LNG will be a valuable addition for the EU to the global LNG market as it strengthens its position as a buyer, further allowing it to push for more flexibility, transparency, and liquidity. This will drive down price and give Europe the ability to strong-arm Russia at lower prices. The probability that Russia will soon be replaced as the most abundant gas supplier is unlikely, but Russia will feel the impact of U.S. LNG on its gas revenue for years to come.

"Russia's Gazprom, in particular, stands ready to stave off U.S. LNG using its unparalleled flexibility in volume and pricing strategy. Expectations are that Russia will be called on for additional supply to Europe as indigenous output continues to fall. In addition, the US faces its own problems in keeping LNG exports to Europe competitive, not least the financial difficulties many gas producing companies find themselves in" (Elliot and Reale, 2017).

1.6. PRICING MECHANISM

In comparison to crude oil, LNG has a less common use in the international market, since there is a lack of substructures such as gasification facilities, liquefaction plants, storage facilities, and ship feasibility. In addition to this, the price transparency of LNG is not consistent around the world, except in a couple of import hubs in specific, high-use regions. Pricing dynamics are considered the most significant obstacle for LNG to continue to increase its market share. However, in order to provide price transparency and an independent pricing mechanism for LNG, a liquid market is necessary. Currently, there are two main pricing mechanisms to determine global prices: oil-pricing index and gas-to-gas pricing. According to the *BP Statistical Review*, the primary pricing hubs of LNG are Japan-Korea Market (JKM) and Japan CIF. Gas pricing hubs such as the Average German Import Price, UK National Balancing Point (NBP), Title Transfer Facility (TTF) in the Netherlands, U.S. Henry Hub and Canada Alberta can also price LNG.

According to the rule of thumb, there is a valid and simple pricing formula for determining U.S. market prices that can be explained as follows: if the price of a British thermal unit (Btu) is 20 USD according to West Texas Intermediate (WTI) oil, then the gas price is determined as $2 per million metric Btu (mmBtu). The ratio can be explained as 10:1. Due to fluctuations in pricing over the years, the most successful ratios have been the ones between 10:1 and 6:1 (Brown and Yucel, 2008). But this formula cannot be scaled to Europe since the primary suppliers of Europe—Russia, Netherlands, and Norway—use an oil-based pricing formula. The corresponding formula includes inflation, crude oil, gasoline, diesel oil, light, and heavy petroleum, coal, and electricity as components. In general, the petroleum index is defined as 35%-39% heavy fuel oil and 52%-55% diesel oil and gasoline. These two products have an impact on pricing of 92% in the Netherlands, 87% in Norway, and 92% in Russia (Kopolyanik, 2011).

Prior to the 1960s, a cost-based pricing method called cost-plus was used in Europe. This method essentially determined the price by adding some level of profit to the cost. After 1960, however, the replacement method started being used, which determined the price based on the service for which it was being used. In the early period, this was gasoline. From the mid-2000s to today, however, commoditization and spot LNG markets have been used more frequently since oil prices do not represent the precise cost of gas. The reason for this transition was that prices of gas increased dramatically more, when compared to costs, than was the case for petroleum.

Europe has never had a market as well supplied as the U.S. Henry Hub; therefore the aforementioned pricing models were used. Even the NBP, which is located in England and is one of the most crucial energy hubs in Europe, has less liquidity in gas than in crude oil. Therefore, the pricing system remains based on crude oil, and the spot markets have not been improved enough in Europe. According to evaluations made in 2015, NBP became a fully liberal market after 14 years of development. However, TTF has been taking steps in order to become a liberal market, but it has not become a complete one yet (Heather, 2015, p. 95).

NBP was the first gas-to-gas pricing method used in Europe, which started in the 1990s. NBP serves a market-gathering role, bringing together buyers and sellers such as NBP financial traders, industrial consumers, LNG suppliers, and petroleum gas producers. In this context, the UK gas market includes LNG tanker sales, pipeline gas sales from Norway and Europe, storage, and UK domestic gas production. Gas pricing per unit can be evaluated in terms of $USD/mbtu and is announced by ICE Futures Europe (Ice Future and Erce).

The TTF is a substantial pricing mechanism growing swiftly, and newer than NBP. The corresponding pricing mechanism is stated as the virtual trading point run by Gasunie Transporter Service (GTS), the transmission system operator of Holland. In the framework of the system, the rights related to trading can be obtained by attorning. Pricing is based on the prices between the first day of the month (06:00) and the first day of the following month. Concerning prices and operations are announced by ICE Futures Europe (Ice Futures).

JKM is an LNG pricing mechanism that was announced by S&P Global Platts on February 2, 2009. The system is based on the bid offers provided on Asian spot markets. The daily pricing method of the mechanism can be evaluated by the formula JPY/MMBtu. This pricing system is being used in Japan, South Korea, Taiwan and China markets (S&P Global).

Japan CIF is another pricing method that was announced according to Japanese Crude Cocktail. ARGUS definied it as JCC$/bbl according to the importation of crude oil announced by Japanese Ministry of Finance. It is announced on the same day that the Ministry of Finance announces related prices, which are usually done one or two months after importation. The LNG price can be explained basically in the S-Curve Formula as follows: $P_{LNG}=a * P_{crudeoil} + b$. The "a" in the formula defines the correlation between petroleum and the gas; "b" defines all other costs; and $P_{crudeoil}$ is considered as JCC (Kawamoto, 2005).

Henry Hub is the American pricing hub used on the New York Mercantile Exchange (NYME) since the 1990s. In this market, natural gas is independent from the supply and demand dynamics of the petroleum market. Due to more liquidity, Henry Hub is the most transparent pricing mechanism in natural gas. Countries such as Australia and Qatar, which are major exporters that have tended towards oil-indexed petroleum, generally determine prices according to Henry HUB when the crude oil prices decrease (Pedersen, 2017).

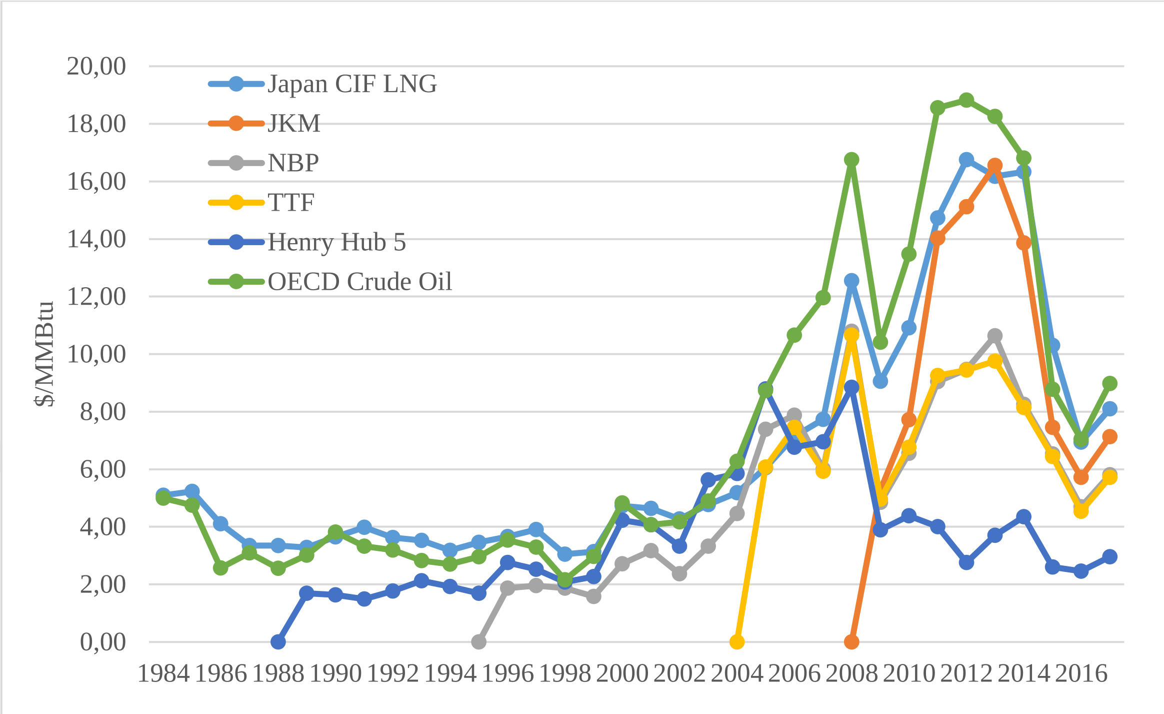


Figure 1.8: LNG, Pipe Gas and Crude Oil Prices $/MMBtu

Source: BP, 2018

If petroleum, pipe gas and LNG prices are evaluated in terms of $/MMBtu, it can be observed that Japanese CIF was the most expensive pricing hub, while Henry Hub was the cheapest one in the 1990s. With the increase of petroleum prices in the early 2000s, crude oil became the most expensive resource. Especially after the petroleum crisis in 2008, prices dramatically increased and the difference between LNG and petroleum prices hit 4$/MMBtu. In 2017, crude oil became once again the most expensive resource. Since the hubs pricing gas are based on crude oil prices, the related increase in crude oil prices led to an increase in LNG prices. JKM, which emerged in 2009, had a lower price compared to Japan CIF, since its pricing was based on bid and offers. Also, it was being used more often in spot market due to lower prices. TTF and NBP have similar prices due to the same resources they draw from. Henry Hub has been the cheapest since 2006 and is currently holding its ground in terms of price. The main reason for Henry Hub having the lowest price is the discovery of shale gas, which made the United States a gas-exporting country, instead of a gas-importing country.

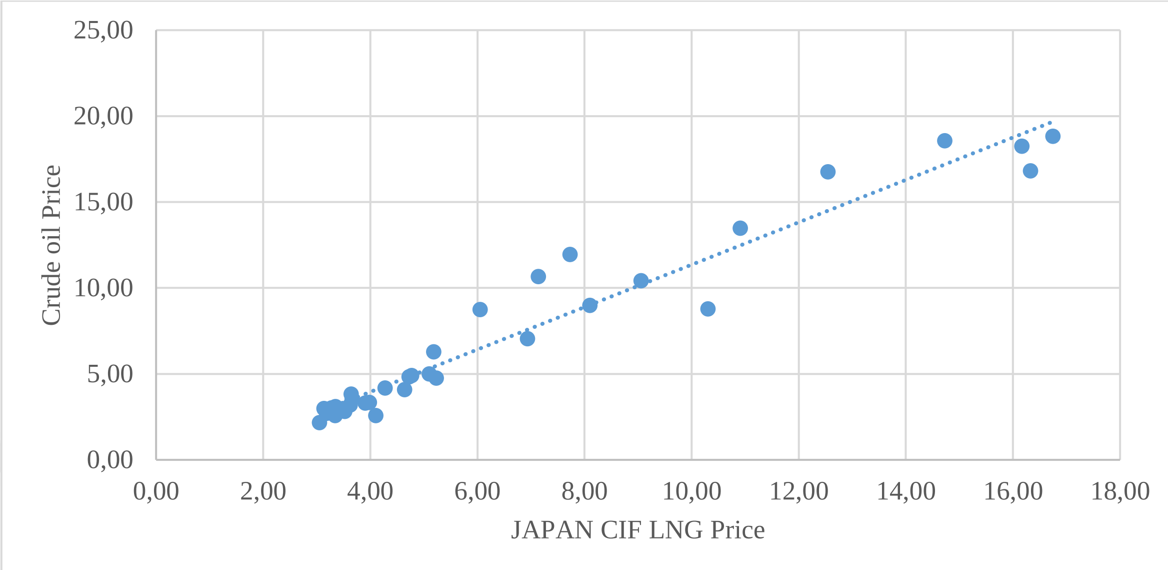


Figure 1.9: Crude Oil / Japan CIF Price Relation

Source: BP, 2018

In the figure above, the relationship between the Japan CIF and crude oil prices can be observed. There is a high correlation between them when the prices are below 5$/mmbtu. But, due to the increase in crude oil prices, correlation decreases, which causes the Japan CIF price to become the lowest. LNG is more similar to petroleum products compared to natural gas, and its trade is possible in the LNG spot markets. The use of LNG will grow worldwide considering the comparative advantage it has against petroleum and crude oil.

CHAPTER 2

TURKISH NATURAL GAS MARKET

After the 1920s, natural gas consumption started to increase around the world, and Turkey began using natural gas, less than 1 bcm, in 1986. In the following years, the market expanded steadily, reaching 51 bcm. The reason for the expansion was the development of distribution and transmission systems and, also, the use of gas-fired plants to produce electricity. Turkey has a geographically advantageous position because it is located between consumers and producers. Therefore, natural gas is an important resource for the Turkish energy market. The following sections will detail the history of the Turkish natural gas market, its market outlook, and the actual and potential natural gas resources for Turkey from which it can draw.

2.1.HISTORY OF NATURAL GAS MARKET IN TURKEY

The first natural gas discovered in Hamitabat in 1970 and it used in Pınarhisar cement factory. However, natural gas reserves and production amount was not enough to spread. The first agreement signed between BOTAS and Soyugazexport (USSR) came in 1986, and the first actual natural gas import was carried out in 1987. In 1988, the first LNG agreement was signed with Algeria for diversity and to ensure supply security. Then, in 1994, the first LNG terminal was established at Marmara Ereğli. In 1995, another LNG agreement was signed with Nigeria. A new pipeline agreement was then signed with Iran in 1996, and the pipeline was completed in 2001. In 1997, a 25-year gas-purchasing contract was signed with Russia for Turkey to receive natural gas through a pipeline under the Black Sea. The new pipeline started flowing in 2003. This agreement was the fourth supply source for Turkey. In 1998, Turkey signed a 25-year gas purchasing agreement with Russia to receive natural gas through Batı Hattı, which was the original transit line for Turkish imports of Russian gas. In 2001, a 15-year gas purchasing agreement was signed with Azerbaijan, ensuring a new supply source for Turkey. Another critical issue was the liberalization of the Turkish natural gas market and the natural gas market law published in the Official Gazette. In 2004, following the law, the processes regarding tenders for metropolitan natural gas distribution were expedited, and Petroleum Pipeline Corporation's (BOTAS) transmission network was opened to third-party access. In 2005, the first tender for contract takeover was made, and, in 2007, the first contract takeover agreement was signed. In 2007, third-party access to the transmission network began. A total contract takeover of 4 bcm was carried out in 2007-2009. In 2007, Petroleum Pipeline Corporation (BOTAS) started exporting natural gas to Greece. Egegaz Aliağa LNG terminal started to import natural gas in 2009. The decision of the Petroleum Pipeline Corporation (BOTAS) in 2011 to decline to extend its natural gas purchasing contract with Gazprom Export for purchasing up to 6 bcm of natural gas per year was an essential development, increasing the share of the private sector. In 2016, the first FSRU started operating, and Etki Liman Isletmeleri (EMRA, 2017) operates it. In the first quarter of 2018, the omnibus bill passed in the parliament, which was significant for realizing the natural gas market. The state gave permission to import spot pipeline gas via BOTAS's contracted countries. After that omnibus bill, the pace of liberalization picked up. In September 2018, EPIAS opened the natural gas wholesale market, the first step towards ending BOTAS' monopoly.

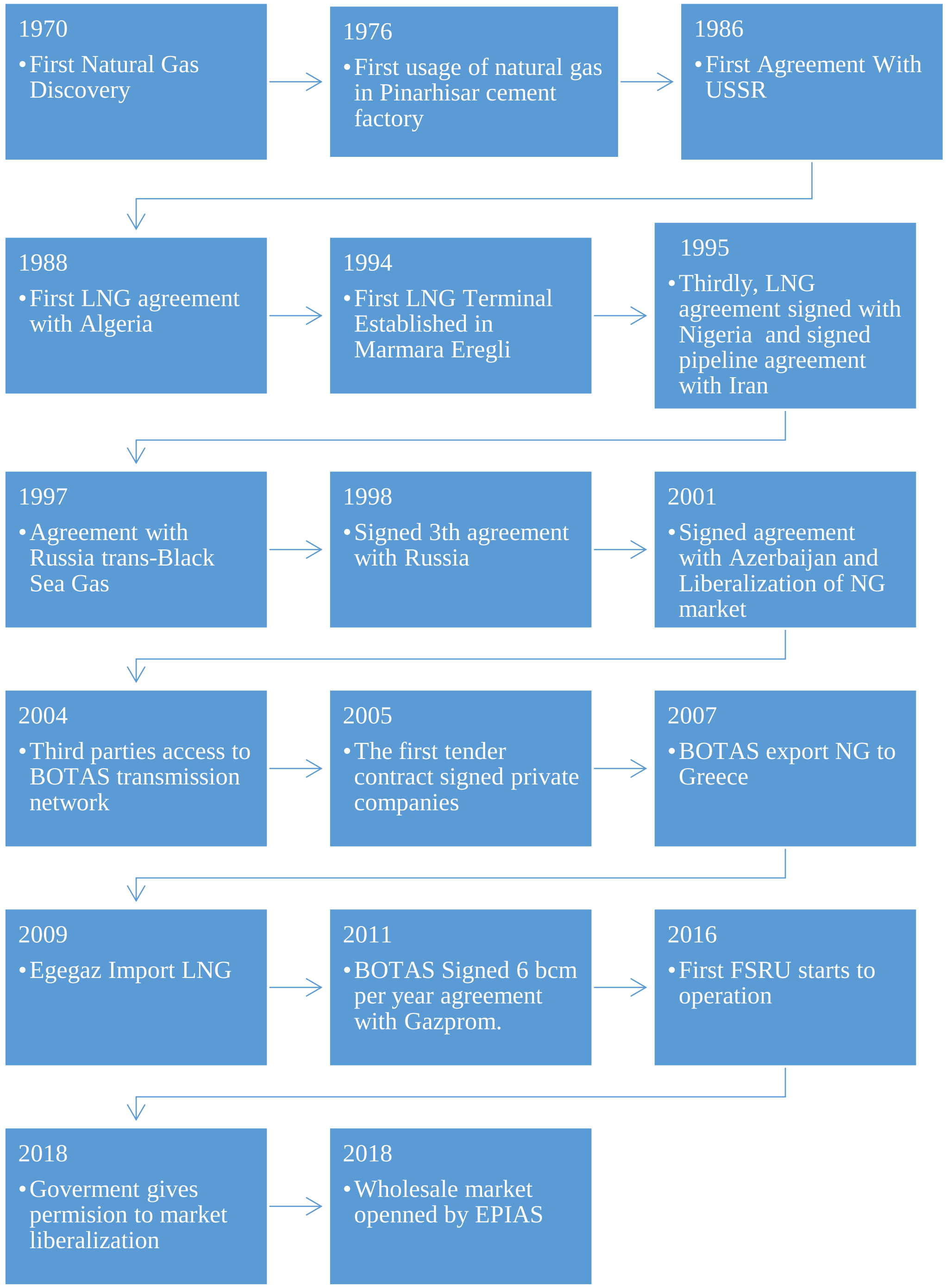


Figure 2.1: Timeline of Turkish Natural Gas Market

Source: BOTAS, 2018

2.2. NATURAL GAS IN ENERGY SECTOR

At the end of 2017, Turkey's energy consumption reached 157.7 Mtoe, and it was 16th biggest consumer in the world (BP, 2018). However, Turkey does not have enough energy supplies to secure its demand, and energy security, supply energy continuously at an affordable price, is a critical issue. Turkey is historically an energy-depended country, with dependency increasing continuously. In 1950, it was the only 8%, and then in 1988, it was 50%; by the end of 2017 it was more than 80% (Berk and Ediger, 2018). Turkey is also a developing country. In 2017, its growth rate was 9.5%, which means that Turkey's energy consumption will increase alongside its energy dependency. Turkey is close to natural gas producer countries, and a large part of the expected increases in energy demand will be covered by natural gas.

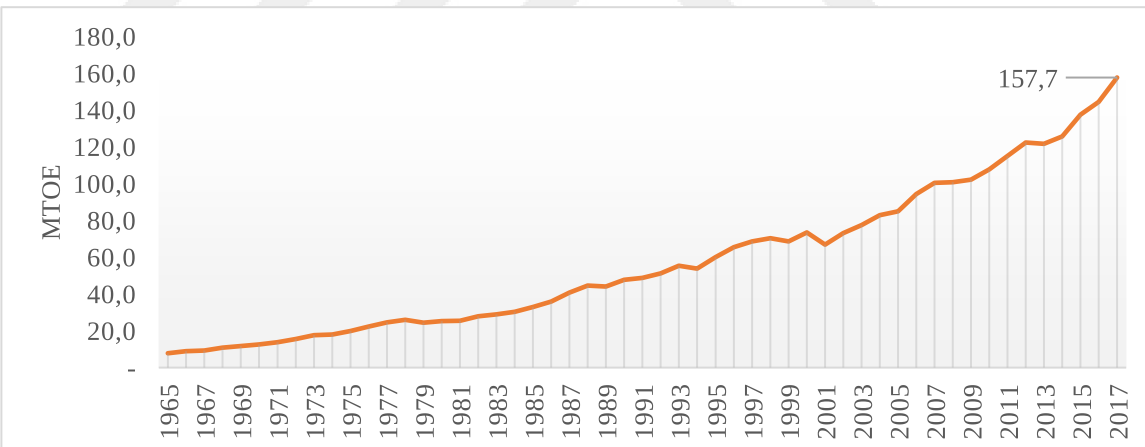


Figure 2.2: Turkey Primary Energy Consumption 1965-2017

Source: BP, 2018

The following table 2.1 shows Turkey's energy sources and the share of each energy source in the primary energy consumption. At the end of 2017, oil was the most consumed source at 48.8 Mtoe, coal at 44.6 Mtoe, and natural gas at 44.4 Mtoe. These three sources supply 87% of Turkey's energy consumption, and natural gas is increasing (BP, 2018).

Table 2.1: Turkey's energy resources

Source	Consumption (Mtoe)	Share
Oil	48.8	31%
Natural Gas	44.4	28%
Coal	44.6	28%
Hydro electric	13.2	8%
Renewables	6.6	4%
Total	157.7	100%

Source: BP, 2018

Natural gas dependency is higher than other products. In 2018, Turkey imported 99.3% of its natural gas consumption from other countries because it does not produced natural gas domestically. Turkey has five pipeline connections, and 80% of its total imports are supplied from these. The leading supplier for Turkey is Russia, which corresponds to 52% of total imports. Also, there is another pipeline under construction between Turkey and Russia called TurkStream.

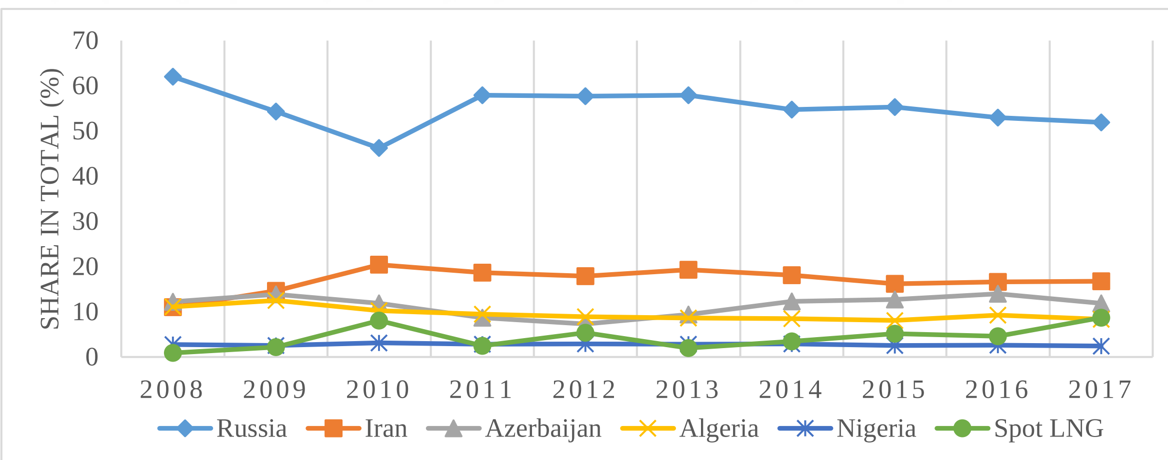


Figure 2.3: Share of Natural Gas Suppliers in Turkey, 2008-2017

Source: EMRA, 2017

At the beginning, Turkey was importing 100% of its natural gas from Russia. Afterwards, diversity of supplies was made a priority, and other countries' share increased gradually, including by spot LNG cargoes. By this progress, Russian gas share was reduced to 53%.

Other suppliers' percentages were 17% Iran, 12% Azerbaijan, 8% Algeria (LTC-LNG), 2.5% Nigeria (LTC-LNG) and 9% spot LNG at the end of 2017.

2.3. TURKISH DOMESTIC NATURAL GAS MARKET AND ROLE OF BOTAS

2.3.1. Turkish Domestic Natural Gas Market

In 2017, 0.354 bcm production of Natural Gas was produce from 10 producer companies in seven different areas, including Tekirdağ, İstanbul, Kırklareli, Düzce, Adana, Çanakkale, and Adıyaman. Total Turkish gas imports were 55.2 bcm, which increased by 19% compared to 2016. Also, in 2017, 10.7 bcm of LNG was imported, which was 19.48% of total gas imports, while 37% of the total imported LNG came from the spot market.

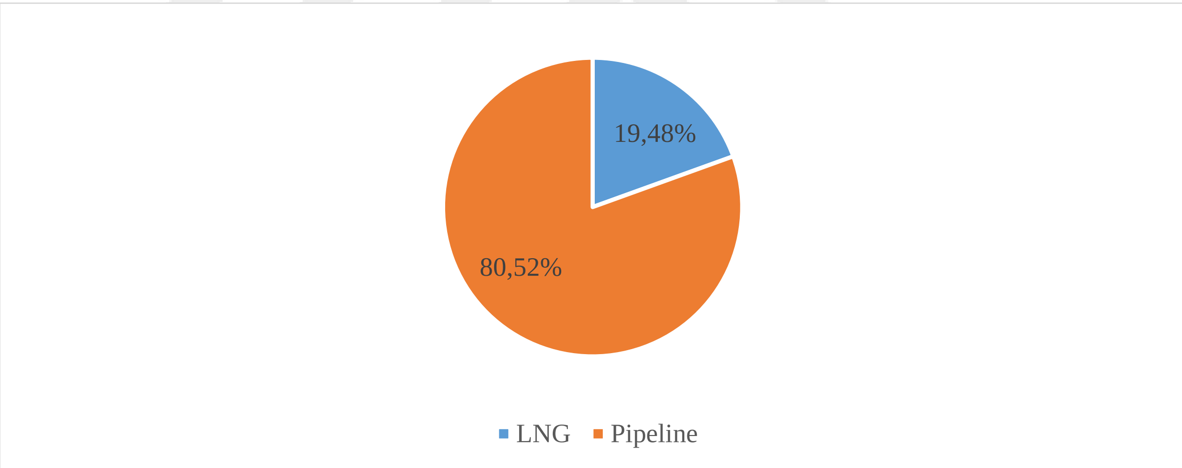


Figure 2.4: The Share of Pipe Gas and LNG of Total Imports in 2017

Source: EMRA, 2017

Figure 2.4 shows that Turkey is a gas-importing country, but has limited import capacity. Eight companies have exporting licenses, but only BOTAS is exporting 0.63 bcm of natural gas to Greece. In 2017, Turkey opened new storage facilities. By comparison, natural gas underground storage capacity increased by around 20% form 2016 to 2017, and LNG storage capacity increased by 76% because of the new FSRU vessel GNL Del Plata, which began operating in Iskenderun Bay.

For 2017, the forecast consumption was 46 bcm but, in 2017 it realized 53.8 bcm; Turkey's consumption was therefore 16% higher than predicted. Also, 0.65 bcm of LNG was directly used by the consumer without using the national transmission network, or roughly 1.2% of total national gas consumption. At the end of 2017, natural gas distribution companies increased their investments by 15.2% to 15 million Turkish liras. Total steel lines increased 113% to 12,326 km, and polyethylene lines increased 9.2% to 81,478 km (EMRA, 2017).

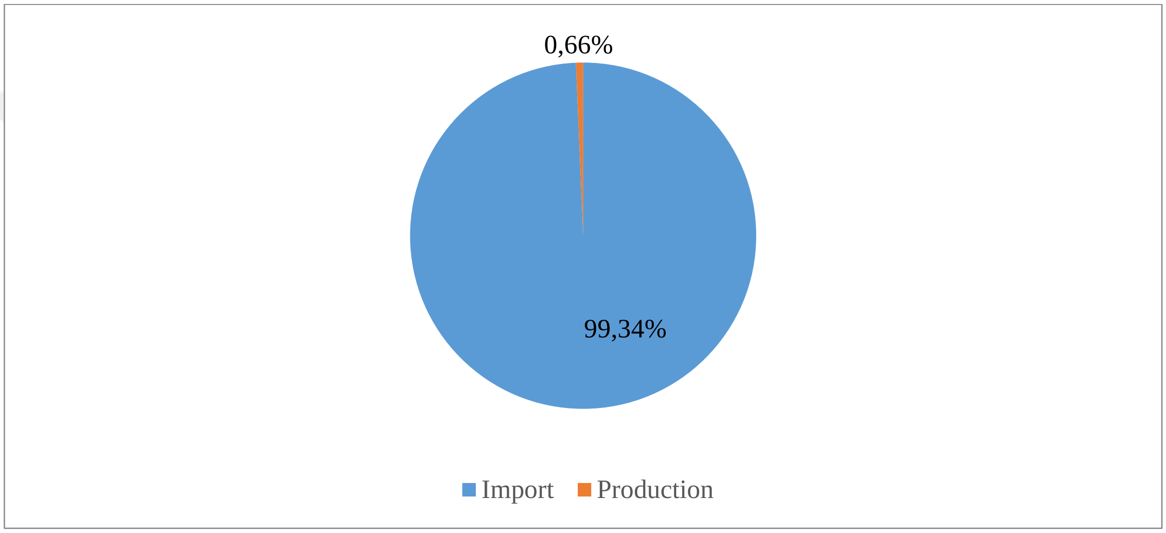


Figure 2.5: The Share of Total Natural Gas Supply in 2017

Sources: EMRA, 2017

Also, seasonal demand is essential factor in analyzing natural gas imports. Demand is related to weather conditions because household demand rises in winter time due to additional heating needs. For this reason, companies imported more natural gas during winter months. Increasing demand affect the industry and other usage areas since during winter the government's priority is household usage and it limits other sectors to prioritize households (EMRA, 2017).

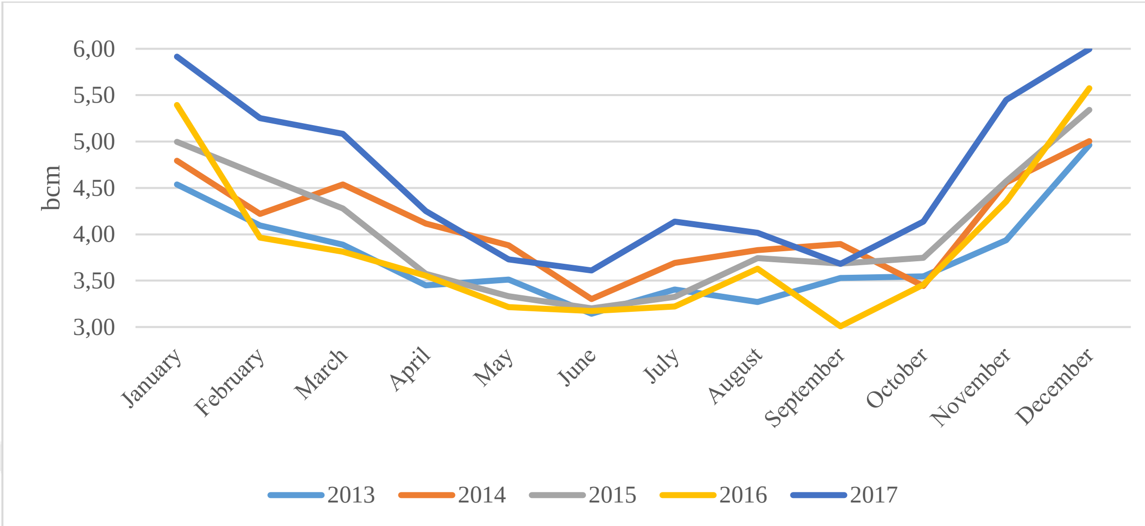


Figure 2.6: Turkish Natural gas Market Seasonal Demand 2013-2017

Sources: EMRA, 2017

At the end of 2017, total gas consumption in Turkey was 53.8 bcm. The conversion sector was 20.5 bcm, industrial power sector 13.37 bcm, households 13.51 bcm, the service sector 3.72 bcm, the energy sector 2,.05 bcm, the transportation sector 0.529 bcm, and other sectors 0.118 bcm (EMRA, 2017).

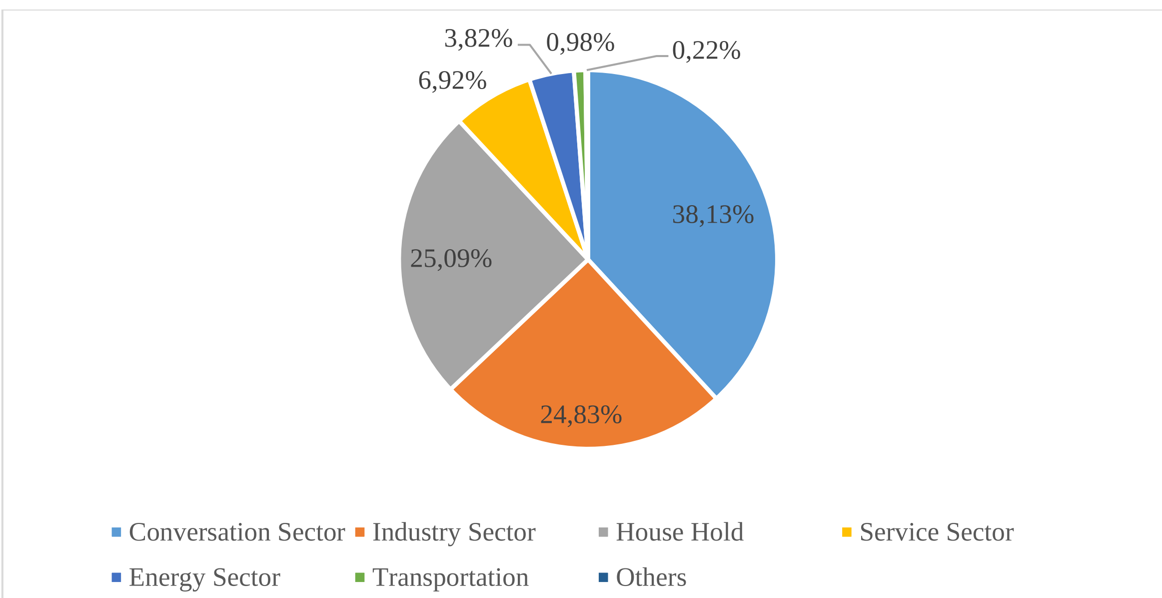


Figure 2.7: The Share of Consumed Natural Gas by Sector

Sources: EMRA, 2017

Figure 2.7 shows that Turkey is using natural gas mainly for the conversion sector, industrial power, and households. Power plants, auto-producer power plants, combined heating and power plants (CHP), auto-producer heating and power plants, heating plants, auto producer heating plants are included in conversion sector. Therefore, power plants generate 94% of the conversion sector. Turkey has 243 natural gas conversion terminals, and it has 23,063.7 MWh loaded electricity generation capacity (TEIAS, 2018) It was 37% of total electricity production and has increased by 5% from 2016 to 2017. Also, it is a major electricity generation source for the Turkey Electricity Market (EXIST, 2017). Woodworking, alcohol and alcoholic products, nonmetallic minerals, iron and steel, nonferrous metal mining and metal working, food and beverages, fertilizers, construction, paper cellulose and printing, chemistry (including petrochemical), mining and quarrying, machine industry, textiles, leather and clothing industry, tobacco products and products itself, and transportation vehicles are the primary businesses in the industrial sector.

Consumption of natural gas increased from 2008 to 2017. At the end of these ten years, Turkey’s natural gas consumption increased roughly 46% to 53.86 bcm. In that year, consumption increased continuously but in 2009, 2015, and 2016, consumption was lower than the previous year. In 2017, consumption increased once again, this time by 16% compared by 2016, and was the highest natural gas consumption recorded in Turkey.

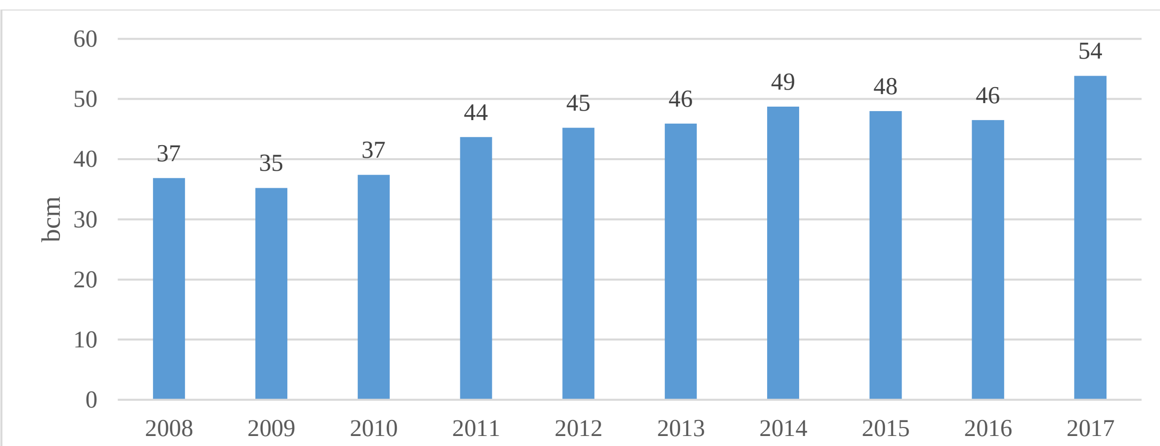


Figure 2.8: Total Turkish Natural Gas Consumption by Year

Sources: EMRA, 2017

2.3.2. BOTAS' Monopoly

The biggest obstacle to creating a competitive natural gas market is the monopoly position of BOTAS, the Turkish state-owned company. With this position, BOTAS controls more than 80% of the market. Before April 2001, it should be noted, BOTAS controlled the entire market, but the "Turkish Parliament passed NGML to liberalize the gas market, abolishing the monopoly of state-owned BOTAS, and allowed private firms to import, distribute and sell natural gas" (Çetin and Oğuz, 2011). According to this law, BOTAS has to sell 10% of its market share every year to domestic companies, but this provision was not instituted until the end of 2017. Until that time, the market remained under its control, as illustrated in the data below.

In 2017, 55.294 bcm of natural gas was imported by nine different companies, while BOTAS imported 82.51% of total import (pipeline gas and LNG).

Table 2.2: The Share of Natural Gas Import by Companies

Company Name	Amount	Share (%)
BORU HATLARI İLE PETROL TAŞIMA A.Ş.	45.584,37	82,51
ENERCO ENERJİ SANAYİ VE TİCARET ANONİM ŞİRKETİ	2.325,01	4,21
AKFEL GAZ SANAYİ VE TİCARET ANONİM ŞİRKETİ	2.082,35	3,77
BOSPHORUS GAZ CORPORATİON ANONİM ŞİRKETİ	2.081,99	3,77
BATI HATTI DOĞALGAZ TİCARET ANONİM ŞİRKETİ	962,07	1,74
KİBAR ENERJİ ANONİM ŞİRKETİ	961,79	1,74
EGE GAZ ANONİM ŞİRKETİ	517,14	0,94
AVRASYA GAZ ANONİM ŞİRKETİ	491,24	0,89
SHELL ENERJİ ANONİM ŞİRKETİ	244,00	0,44
Total	**55.249,95**	**100**

Sources: EMRA, 2017

There were also 43 companies holding import (spot LNG) licenses in 2017. Only two of them, BOTAS and EgeGaz, imported spot LNG that year. Of the remaining 40 companies, 12 sold gas supplied from the domestic wholesale market. The remaining 28 companies had no operation within the scope of their licenses in 2017 (EMRA, 2017). EgeGaz started importing LNG in 2008, breaking BOTAS's monopoly on the LNG market.

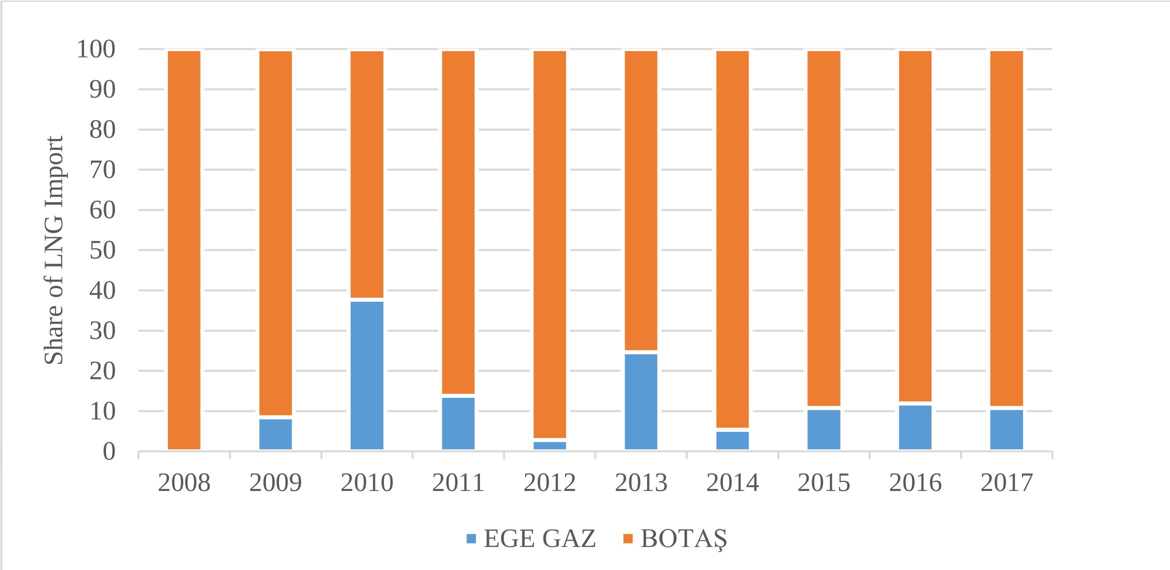


Figure 2.9: The Share of Spot LNG Importers between 2008-2017

Sources: EMRA, 2017

Wholesale and supply, mainly control from BOTAS. End of 2017 80.39% of wholesale under control of it. For liberal market is based on the ground of creating competition at commercial facilities which have competitive dynamics. For this reason, it is essential that many market players should be increased and governing structures should be avoided. By the end of 2017, there were 49 licensed wholesale companies. One of them was the natural gas production company, while 16 of them were not operating within the scope of their license.

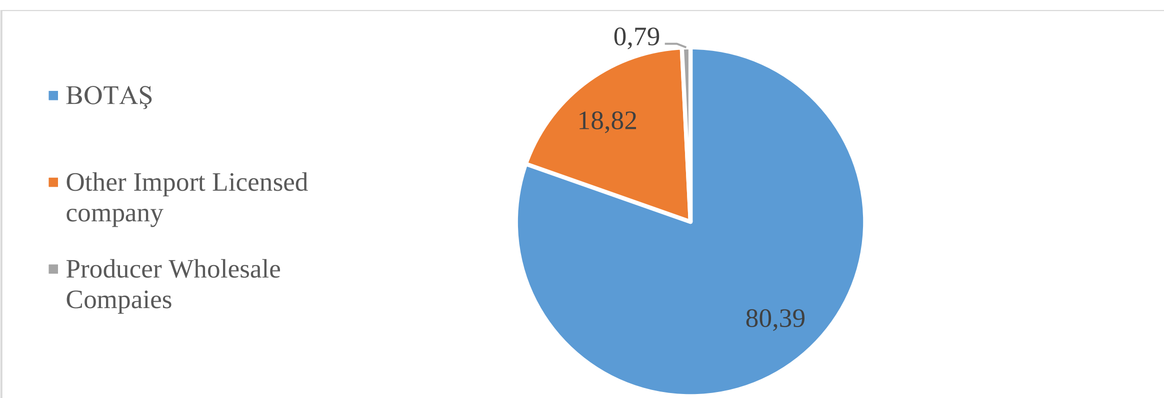


Figure 2.10: The Share of Import and Production Companies in Natural Gas Supply in 2017

Sources: EMRA, 2017

In 2017, 95.34% of gas sales were made to companies with import and wholesale licenses. The share of the companies that have an import license was 79.51%. Those 75 companies supplied the aforementioned 44.2 bcm gas. The ten companies that supplied the largest amounts are given in Table 2.3.

Table 2.3: The Share of Ten Largest Supplier

Trade Name	Amount of Sales	Share (%)
BOTAŞ (BORU HATLARI İLE PETROL TAŞIMA ANONİM ŞİRKETİ)*	19.469,11	46,04
ENERCO ENERJİ SANAYİ VE TİCARET ANONİM ŞİRKETİ	2.522,62	5,97
AKFEL GAZ SANAYİ VE TİCARET ANONİM ŞİRKETİ	2.267,73	5,36
BOSPHORUS GAZ CORPORATİON ANONİM ŞİRKETİ	2.009,83	4,75
EWE ENERJİ ANONİM ŞİRKETİ	1.880,40	4,45
DOĞAL ENERJİ İTHALAT ANONİM ŞİRKETİ	1.560,06	3,69
AKFEL ENERJİ TİCARET ANONİM ŞİRKETİ	1.270,51	3,00
KİBAR ENERJİ ANONİM ŞİRKETİ	967,71	2,29
BATI HATTI DOĞALGAZ TİCARET ANONİM ŞİRKETİ	966,65	2,29
GLOBAL MADEN DOĞALGAZ PETROL VE KİMYA SAN. VE TİCARET ANONİM ŞİRKETİ	771,26	1,82

Sources: EMRA, 2017

"The transmission of natural gas via pipelines is conducted by BOTAS in Turkey. According to the Natural Gas Market Law, it is projected that public legal entity character of transmission company, which will be one of the companies ensued as the result of the restructuring of BOTAS as a horizontally integrated legal entity, will continue" (EMRA, 2017, p. 32).

Distribution is the only privatized phase in the natural gas market. "Local distribution of natural gas may be arranged by a company that wins the tender to be launched by the authority, and the duration of the license will be determined by the EMRA" (Rzayeva, 2014).

2.4. ACTUAL AND POTENTIAL NATURAL GAS SOURCES FOR TURKISH MARKET

2.4.1. Actual Sources

Turkey has a geographically important location: it neighbors large natural gas importers such as Russia, Iran, and Azerbaijan, which supply natural gas to Turkey. The Western Line, Blue Stream, Eastern Anatolian, and Baku-Tbilisi-Erzurum are the main pipelines that bring gas to Turkey. Turkey is buying 80% of its natural gas imports by pipelines, and Russia is the largest supplier. Turkey imported 52% of its natural gas from Russia in 2017. Table 2.4 shows BOTAS' long-term contracts with suppliers

Table 2.4: BOTAS' Long-Term Contracts

Current Agreement	Volume (bcm/year)	Date of Agreement	Status	End Date
Algeria (LNG)	4.4	1988	In Operation	2024
Nigeria (LNG)	1.3	1995	In Operation	2021
Iran	9.6	1996	In Operation	2026
Russia (Blue Stream)	16	1997	In Operation	2025
Russia (West)	4	1998	In Operation	2021
Turkmenistan	15.6	1999	Pending	-
Azerbaijan (Phase 1)	6.6	2001	In Operation	2021
Azerbaijan (Phase 2)	6	2011	In Operation	2032
Azerbaijan (BIL)	0.15	2011	In Operation	2046

Source: Petform, 2018

Figure 2.11: Turkish Pipelines and Planned Projects

Source: MENR, 2018

Russia-Turkey Natural Gas Pipeline (Western Line);

As a consequence of the pursuit of different energy resources, the Republic of Turkey made an intergovernmental agreement regarding the natural gas delivery issue with the former Soviet Union on 18 September 1984.

After the agreement was made, similar studies were initiated by BOTAS with the help of the Natural Gas Usage Survey results, which were acquired in 1985 and detailed the potential natural gas consumption in the country. The proper route for the pipeline was decided at this time. In this framework, a 25-year natural gas-purchase contract was signed between BOTAS and Soyuz Gaz Export on 14 February 1986. Under the contract, natural gas imports commenced continuously in 1987 and hit maximum capacity, which was 6 bcma in 1993.

The 845-km Russia -Turkey Natural Gas Pipeline enters Turkey in Malkoçlar on the Bulgarian border, and follows a route through Hamitabat, Ambarlı, Istanbul, Izmit, Bursa and Eskişehir before ending in Ankara.

With the initiation of construction on October 26, 1986, the pipeline reached to its first stop, Hamitabat, on 23 June 1987. From this date, in addition to the domestic natural gas, imported natural gas was used in electricity production at the Trakya Combined Cycle Power Plant in Hamitabat. The line reached Ankara in August 1988. Natural gas was then used in IGSAŞ (Istanbul Gübre Sanayii A.Ş.) in July 1988, in the Ambarlı Power Plant in August 1988 and in residential and commercial areas of Ankara in October 1988.

During the process, the capacity of the Malkoçlar metering station on the Bulgarian border was increased from 8 bcma to 14 bcma (MENR, 2018).

Blue Stream Gas Pipeline;

Under the 25-year natural gas purchase-sale agreement between BOTAS and Gazexport on December 15, 1997, natural gas was supposed to be transported from Russia through a transit line under the Black Sea connecting to Turkey. As stated in the agreement, 16 bcma was supposed to supply to Turkey.

The Blue Stream Gas Pipeline construction was divided into three main sections:

- Russian territory contains the 370-km pipeline system between the Izobilnoye-Djubga, includes a 308-km, 56-inch pipeline and a 62-km, 48-inch pipeline,
- Where the pipeline connected to the Black Sea, between Djubga and Samsun, two 390-km, 24-inch parallel lines were laid.
- In Turkey, between Samsun and Ankara, a 501-km, 48-inch pipeline was laid.

Furthermore, Gazprom provided the construction and financing of the main sections located in Black Sea pass and Russia. The construction and financing of the section in Turkey was provided by BOTAS. The construction of the pressure reducing and metering station in Samsun-Durusu was completed on 15 October 2002.

The section of Blue Stream located in Turkey starts from Samsun and connects to the main transmission system in Ankara through Amasya, Çorum, and Kırıkkale. The pipeline was opened on 20 February 2003, but a ceremony held on 17 November 2005, in order to celebrate the opening officially (MENR, 2018).

Eastern Anatolian Natural Gas Main Transmission Line (Iran-Turkey);

A natural gas purchase-sale agreement was made between Iran and Turkey on 8 August 1996 in Tehran in order to supply 10 bcm annually from Iran to Turkey via pipeline. The 1491-km Eastern Anatolian Natural Gas Main Transmission Line, has a diameter that rnages from 16 inches to 48 inches. The pipeline runs from Doğubeyazıt and connects to Ankara via Erzurum, Sivas, and Kayseri. It also has branches to Seydişehir via Kayseri and Konya.

At the end of 2001, the pipeline system was constructed and ready to transfer gas. The gas trade from Iran was commenced on 10 December 2001, after the finalizing of the Meter Station in Bazargan (MENR, 2018).

Baku-Tbilisi-Erzurum Natural Gas Pipeline (BTE)

With the purpose of supplying natural gas from the Shah Deniz field in the southern Caspian Sea region of Azerbaijan to Turkey, the Baku-Tbilisi-Erzurum pipeline was opened based on the Turkey-Azerbaijan Intergovernmental Agreement made on 12 March 2001. According to this agreement, BOTAS and SOCAR made a 15-year natural gas purchase-sale agreement for the transportation of 6.6 bcm.

Construction of the 980-km, 42-inch BTE pipeline began on 16 October 2004 and was ready to transfer gas on 4 July 2007. The pipeline is located in the corridor of the Baku-Tbilisi-Ceyhan Crude Oil Pipeline (BTC) in the territories of Azerbaijan and Georgia.

An expansion of the BTE gas pipeline began in 2015 to increase the production rate and capacity of the Shah Deniz field. Phase 2 of the BTE is located in Azerbaijan and Georgia (South Caucasus Natural Gas Pipeline) (MENR, 2018).

Interconnector Turkey-Greece-Italy (ITGI);

The first phase of the Southern European gas link, known in the past as the Southern Corridor, is the pipeline system that aims to connect the natural gas pipeline systems of Greece and Turkey to each other so that gas can be conveyed from and through Turkey to Greece in the framework of INOGATE (Interstate Oil and Gas Transport to Europe) program. With the purpose of realizing this pipeline connection system, a 15-year purchase-sale agreement was made between the Greek company DEPA and BOTAS on 23 December 2003. The pipeline system started supplying and transferring gas with an opening ceremony that was attended by the prime ministers of Greece and Turkey on 19 November 2007.

In addition, a planned extension of the pipeline is planned to Italy from Greece. With regard to this, an intergovernmental agreement was made between Italy, Turkey, and Greece on 26 July 2007. However, despite the fact that there has been no progress made since then, it is considered that new opportunities may emerge later in order to realize the pipeline connection to Italy (MENR, 2018).

Trans-Anatolian Natural Gas Pipeline (TANAP);

In order to meet the increasing demand for natural gas, negotiations were held between the Azerbaijan government and the Shah Deniz Consortium, which manages the Shah Deniz field. An agreement was reached on 25 October 2011 to supply 6 bcma of Azeri gas to Turkey.

Final decisions about the Shah Deniz Phase II development, the Southern Caucasus Pipeline Expansion (SCPX) Project, TANAP Project, and the Trans Adriatic Pipeline with the investment of 45 billion dollars were made in 2013 with a ceremony in Baku. With those decisions made, the Turkish government was finally able to transfer Azeri gas to Turkey and on to Europe through it. Turkey holds a share of 19% of the Shah Deniz Phase II Project and the Southern Caucasian Pipeline Expansion Project and a 30% share of TANAP via BOTAS. Hence, Turkey now plays a functioning role in the gas production system from the wellhead to the end consumer. With the initiation of TANAP, a 1,850-kmpipeline will be constructed with the capacity of 32 bcm from Georgia to the Greek border. The project is run by TANAP Doğalgaz İletim A.Ş, in which BOTAS has 30% share, SOCAR 58%, and BP 12%.

On 17 March 2015, the groundbreaking ceremony arranged by Turkey was held in Kars, with the attendance of numerous countries' presidents and prime ministers, including the United States and European Union countries. The inauguration of the project, again arranged by Turkey, was then held in Eskişehir/Seyitgazi on 12 June 2018, with heads of state, prime ministers and ministers of energy of many countries, executives of energy companies and senior bureaucrats in attendance. The first gas flowed to Turkey at the end of June and gas supply to Europe is predicted to start in 2020 (MENR, 2018).

LNG Sources;

Turkey has two long-term LNG contracts with Algeria and Nigeria and buys LNG on the spot market. Turkey was importing 10.9 bcm of LNG in 2017, its highest-ever import total. and became the seventh largest LNG consumer in the world in 2017 (BP, 2018). At the same time, regasification capacity has grown from 0.034 bcm in 2015 to 0.117 bcmi in 2017, an 334% increase.

The Marmara Eregli Terminal, operated by BOTAS, was the first LNG terminal in Turkey. It has three main parts: vessel discharging, LNG storage, and regasification. Also, in 2007, six road truck loading arms were built, which will facilitate the transportation of LNG to remote, hard-to-reach parts of the country.

The second LNG terminal, the Ege Gaz Aliağa LNG Terminal, started to operate in 2006. It also has a vessel discharging, LNG storage, regasification, and road truck loading arms.

Etki FSRU (Izmir) started operations in 2016 after the warplane crisis with Russia and is important for source diversification and decreasing dependency on Russia, Turkey's main gas supplier. The storage capacity of the terminal is 145,000 cm and nominal regasification capacity of 500 mmscfd. Its annual operation capacity is 4.1 mtpa (Songhurst, 2017).

The Iskenderun FSRU (Del Plata) started operating in 2018. It has the largest storage capacity in the world with 263.000 cm and nominal regasification capacity 500 mmscfd. Annual operation capacity is 4.1 mtpa (Songhurst, 2017).

LNG supplies arrive from many different sources. Algeria was the first LNG exporter in the world and Turkey signed a long-term contract with Algeria in 1988 for 4.4 bcma. The first imports arrived in 1994, and the contract will until October 2024.

Nigeria is the fourth largest LNG supplier in the world and its exports totaled 27.8 bcm in 2017. It is the second long-term LNG supplier for Turkey. In 1994, Turkey's signed its second LNG supply contract with Nigeria, for 1.3 bcma, and imports started arriving in 1999 (Rzayeva, 2018). Also, Turkey buys spot LNG from Nigeria.

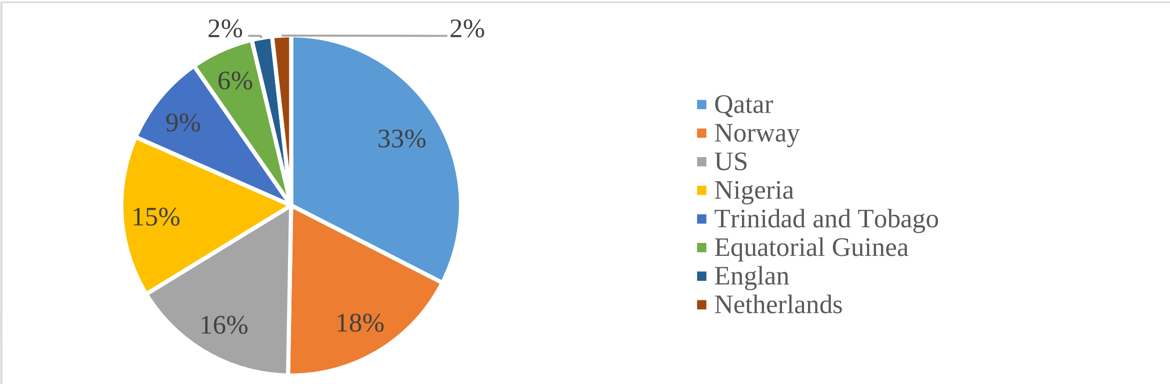


Figure 2.12: The Share of Spot LNG Supplier Countries

Source: EMRA, 2017

The spot LNG market creates alternative suppliers and competitive prices. This is important because the pricing mechanism is clearer and similar in practice to the trade in oil products. Turkey imported 4.8 bcm natural gas from spot LNG market in 2017, the highest-ever volume of spot LNG import for the country. That year, Turkey imported LNG fom eight different countries: Qatar (1.6 bcm), Norway (0.85 bcm), United States (0.76 bcm), Nigeria (0.74 bcm), Trinidad and Tobago (0.42 bcm), Equatorial Guinea (0.29 bcm), England (0.09 bcm) and Netherlands (0.09 bcm).

Qatar is the world's largest LNG supplier, accounting for 27% of global exports. In recent years, Turkey and Qatar have developed close relations, and the LNG trade is an important and trending component of their bilateral relationship. Qatar and Turkey do not have any long-term contracts for LNG, but Turkey is importing Qatari LNG from the spot market. Also, Turkish regasification capacity is not enough to handle more volumes of LNG, so it has to increase its receiving capacity before it can grow its gas relations with Qatar.

2.4.2. Potential New Sources of Gas

TurkStream Gas Pipeline Project

With the purpose of providing political support and determining the technical, economic and legal structure of the TurkStream Gas Pipeline Project, an intergovernmental contract was signed in Istanbul on 10 October 2016 between the Republic of Turkey and the Russian Federation. The contract was signed in the presence of the Russian and Turkish presidents, which legally cleared the way to begin building the pipeline.

TurkStream is a new gas pipeline network that runs from Russia under the Black Sea to the receiving terminal on the Black Sea coast of Turkey and then continues across Turkey to the Bulgaria border. The network has a maximum capacity of 31.5 bcma for two pipelines, each having a capacity of 15.75 bcma. The primary purpose of the project is to supply Russian gas to Turkey, but it also aims to transit gas to Europe via the onshore section and offshore sections. Russia will operate the onshore section, while BOTAS will operate the offshore section. A new, joint venture company between the two countries, with each country having a 50% share, will run the other line' onshore section.

The recent disagreement on natural gas trade between Russia and Ukraine, however, poses a danger to the gas-supply security of Turkey since it could interrupt Russian supplies from the West Line, especially during winter. Upon commissioning The 14 bcma of gas that is transferred through Western Line will now be delivered through TurkStream without any changes in the contract. Hence, this will guarantee that Russian gas reaches Turkey without the use of the transmission system of another country and therefore will not be exposed to possible cut-offs or threats caused by third parties.

The construction of the first line of Turk Stream to Turkey and the second line to Europe are ongoing. The pipelines are expected to open at the end of 2019.

East-West Gas Corridor (Iraq-Turkey Gas Pipeline)

Northern Iraq and Turkey already have oil pipeline. Northern Iraq has 5.67 tcm natural gas reserves (MNR.KRG, 2018). For that reason, Iraq possesses a highly potential to be a gas supplier for Turkey. The idea for a gas pipeline began on 26 December 1996, and it was agreed that BOTAS-TPAO and Tekfen would work on the project, including field development, production, processing and carrying gas via pipeline from Northern Iraq. The aim of the project was to transport ten bcma of gas to Turkey and then transporting some additional gas to the European Union (Ozturk et al, 2011). In the middle of 2017, the Russian oil and gas company Rosneft signed a natural gas production contract with Iraqi Kurdistan before the Kurdish Referendum for independence. Rosneft aim is the same as BOTAS-TPAO and Tekfen: to transport natural gas to Turkey and then on to the European Union. However, these projects are on hold because of political instability in Iraq.

Eastern Mediterranean Gas Pipeline

The importance of the Eastern Mediterranean area in gas has grown in recent years due to new discoveries. Up until now, three countries have explored for natural gas. The first was Israel, which discovered the Leviathan field (509 bcm) and Tamar field (283 bcm). In addition to this basin, there are eight additional discoveries under the authority of Israel with total proved reserves of nearly 1 tcm. The second country to discover gas in the Eastern Mediterranean was Cyprus. Cyprus explored Aphrodite Basin in 2011, where it found reserves of 198 bcm. The third country was Egypt, which explored the great Zohr Basin, with reserves of 850 bcm.

Total proven natural gas reserves in the Eastern Mediterranean total more than 2 tcm. Lebanon also started to investigate its offshore gas potential but has not found any reserves yet. However, there is optimism that these efforts will prove positive. While the Eastern Mediterranean countries continue to explore, problems are emerging, including those pertaining to Exclusive Economic Zones (EEZ). Even though the United Nations Convention on the Law of the Sea (UNCLOS) gives clear definitions to demarcate EEZs, the issue is still contentious and undermines the natural gas exploration and commercialization process. When the natural gas reserves take into consideration, the critical basin is Leviathan, since there is no solid plan to export Zohr's natural gas because of Egypt's own high demand for gas will consume. Cyprus, meanwhile, has a plan to export gas because the reserves of the Aphrodite field are not enough to commercialize it. Therefore, the Leviathan field attracts the most attention and the route of Leviathan gas will determine the natural gas network in the Eastern Mediterranean. One of the most feasible routes is Israel-Cyprus-Turkey. After the pipeline reaches Turkey, it can then connect with TANAP and TAP. Nevertheless, this scheme will require significant capital investment.

At the same time, Turkey's natural gas demand continues to rise. Besides the EU option, Turkey alone could be the final destination of Leviathan gas, and three companies – Zorlu, Enerjisa, and Turcas – are ready to be stakeholders of such a project. According to their offers, dual, 24-inch offshore pipelines that run between 450km and 500 km can be constructed for $2.5 billion from Leviathan to the Turkish port of Ceyhan (Arınç and Özgül, 2015, p. 130-133). According to studies by Turcas, with an additional $647 million, the pipeline can extend from Ceyhan to TANAP and thus carry 16 bcma to Turkey (Bryza, 2013, p. 39).

Two other reasons make this project compelling; (1) it can be completed in a shorter time than any other pipeline route and (2) it can pass through Cyprus and take on gas from the Aphrodite basin, which can then be sent to the EU.

2.4.3. The Necessity of Source Diversification for Supply Security

Natural gas supply and demand are essential for countries with high levels of demand like Turkey. Turkey is a developing country, and energy demand is increasing every year, so Turkey attempts to secure its energy supplies. However, the country's alternatives are limited. Turkey imports 80% of its gas via five different pipelines, which creates a supply security problem since Turkey's storage capacity is limited. Moreover, the flow of gas can be cut off due to forces like terrorism, technical problems, or inter-governmental disputes. In order to secure a continuous supply and meet its growing needs, Turkey should create alternative sources and increase storage capacity. LNG is meeting the daily need and seasonal demand, and many countries are interested in investing in LNG facilities. FSRU investments are particularly vital for increasing the share of LNG because these terminals give would Turkey flexibility to manage its operations. Increasing regasification and storage capacity of

Turkey would also help increase the share of LNG, and therefore reduce Turkey’s dependence on Russia, Iran, and Azerbaijan. LNG can be imported from the spot market from around the world without a long-term contract. Also, “BOTAS and Qatar’s national oil company ensure Turkey’s long-term and regular LNG imports from Qatar” (Widdershoven, 2017, 4).

Another important issue is storage capacity and determining the proper amount to invest. Depending of the source type, BOTAS and private companies can invest in storage. For this, it will be useful to forecast future investments and the share of sources in the market.

2.5. POTENTIAL OPPORTUNITIES FOR TURKISH LNG MARKET

2.5.1. Becoming An Energy Hub

Energy hub means a trading center of energy. Becoming a natural gas hub is a crucial project for Turkey. Turkey has geographically advantages, being between both producer and consumer countries. In its goal to become a hub, LNG trade is as important as pipeline gas trade. If Turkey only uses pipeline sources, it can be no more than an energy-transit country. In this way, Turkey can only receive a fixed fee for every cubic meter that passes through the country. Turkey wants to be an energy and trading hub. When a country stores and resells gas onto the international market, this constitutes energy trade. LNG is stored in cryogenic tanks and sold in the spot market around the world. For this reason, the LNG trading mechanism is different than for pipelines, and is like an oil product. Finally, the pricing mechanism must be transparent in a hub, but LNG is already priced with an oil index in Turkey, which blocks the independence of LNG pricing. For more transparent prices, the number of natural gas importing companies must increase and BOTAS’s market share must decrease. Also, the natural gas trade should start in the stock market. All real and future trades will then create more liberal prices.

2.5.2. LNG Bunkering

Bunkering is fueling ship tanks with small vessels. Bunkering is very important and a huge business. The fuel and bunkering systems are changing according to the International Maritime Organization (IMO) new rules set to take hold in 2020. International shipping has emitted more than 1 billion tones of CO_2, which was approximately 3% of global emissions between 2007 to 2012. The estimated increase is 50% between 2012 to 2050 (Smith et al., 2014). In 2008, the IMO set regulations for marine fuels. They focused lowering sulfur limits. The world merchant fleet creates more than 1.12 billion tons of CO_2, which is 4.5% of the total greenhouse gas emissions (Vidal, 2008). In January 2012, the IMO decided to reduce sulfur limits from 4.5% to 3.5%. In October 2016, IMO decided to further reduce sulfur limits from 3.5% to 0.50% by 1 January 2020. That decision took on IMO's Marine Environment Protection Committee (MEPC 70) (IMO, 2016). The IMO wants to prepare research about alternative fuels that have fewer negative environmental impacts. It worked with SSPA Sweden and published a report in 2012 called "Feasibility Study on LNG Fueled Short Sea and Coastal Shipping in the Wider Caribbean Region." According to the report, the IMO allowed LNG to be an alternative fuel for ships. According to a study prepared by Wood Mackenzie, the shipping industry bunker cost could rise to $60 billion in 2020. LNG should be cheaper than 0.50% sulfur fuel oil. Also, the carbon emission levels will be lower than fuel oil (Jordan and Hickin, 2017). According to these regulations, the number of LNG-based vessels will increase, and there will be a new market called LNG bunkering, in which LNG fuel will be provided by small vessels to bigger vessels. This is also a significant market opportunity for Turkey. At the end of 2017, the Turkish bunkering market was around $1.5 billion, and 55,000 ships passed the Bosporus (Utikad, 2018). This market increases the value of the LNG market in Turkey and is another reason that Turkey should increase its LNG imports in the next decade.

2.5.3. LNG Fuel

LNG is a new fuel for heavy-duty trucks, buses, and waste-collection trucks. "LNG offers a higher thermal efficiency and lower specific energy consumption than gasoline and oil. Hence it is expected as a promising fuel for the future" (Kumar et al., 2011). The calorific value of LNG is 25 MJ/L, diesel is 38.3 MJ/L, gasoline is 34.5 MJ/L, and LPG is 25.4 MJ/L. These values and price performance are looking attractive enough to use LNG in the transport sector. Already, 3,000 LNG-based vehicles owned by the government are operating in the UK. Also, the government has 40 fueling stations at the same time. According to studies, gas fuels reduce GHG emission 10-20% compared to the diesel (Graham et al., 2008). It also has fewer emissions throughout its life cycle compared to coal. If it is clean coal, gas reduces GHG emissions by 73%, but if it is dirty coal, it reduces GHG emissions by 161% (Pace, 2009). According to this, Turkey should use LNG instead of oil products for heavy duty trucks and buses.

2.5.4. Feedstock of Petrochemical Plant

Natural gas-based petrochemical plants are increasing in number around the world, and Turkey has a huge trade deficit with regard to both value and quantity base. Its polypropylene foreign trade deficit was $2.69 billion (2.11 million tons) in 2017 with an average increase of 11.5% on average in the 2013-2017 period. The trade deficit decreased from 2016 to 2017 by 8.8% in quantity terms, but increased by 34.7% in value terms (Pagev, 2017). Increasing demand will continue to affect the trade deficit, as expected demand growth AAGR between 2017-2020 is around 5% per year. However, installed capacity in Turkey is 144 kt/a, only 7% of the demand. The main polypropylene exporters to Turkey in 2017 were Saudi Arabia, South Korea, Egypt, and Israel. In this situation, some private companies are already producing polypropylene. Moreover, the Turkish government gave super incentives in April 2018, demonstrating their interest in this sector, and gave one intensive for a polypropylene production project. The following figure explains the technical evaluation of natural gas to polypropylene production.

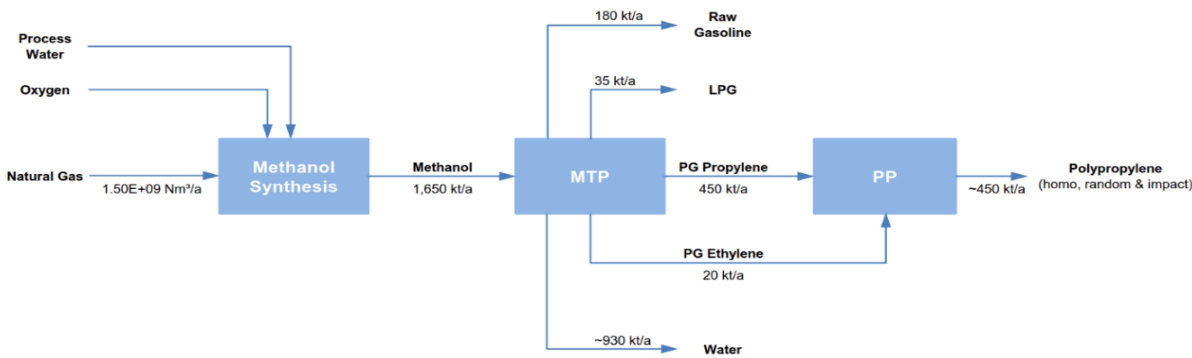


Figure 2.13: Technical Evaluation of Natural Gas to Polypropylene Production

Source: ILF, 2018

This polypropylene production facility can produce 450 kt/a and needs 1.5 bcm natural gas feedstock, which is around 3% of total natural gas imports. The system uses that gas to produce 1,650 kt of methanol, the amount of product input of the MTP (Methanol to Propylene) cracker. Outputs are 450 kt/a PG propylene, 180 kt/a raw gasoline, 35 kt/a LPG, and 20 kt/a PG ethylene. PG propylene and PG ethylene are the input of the PP (Propylene to Polypropylene) cracker. The final product is 450 kt/a PP (ILF, 2017). That amount is around 20% of Turkey's total polypropylene imports, and Turkey needs at least four PP production facility. Therefore, these production facilities need six bcm of gas, which was 12% of Turkey's consumption in 2017. These plants will increase the important volume of natural gas. These terminals need natural gas 24 hours a day and seven days a week, and therefore need emergency stocks. LNG is the best option for storage and main usage. In that projection, LNG is an important and valuable source to supply petrochemical plants (ILF, 2017).

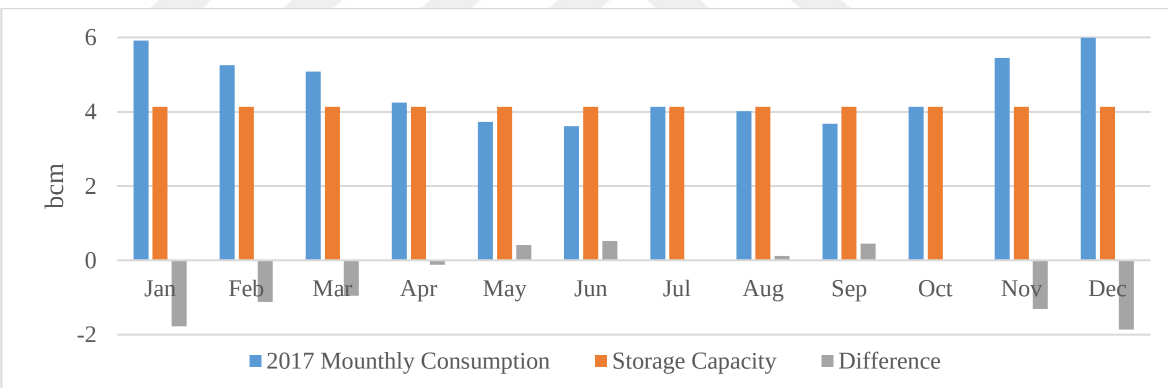
2.5.5. LNG Export to The Balkan Countries

The Balkan countries (Bulgaria, Romania, and Macedonia) do not have a developed pipeline transmission system. For that reason, the industrial sector, some small villages, and hotels have no connection to the transmission system. At this moment, these users are using CNG. However, the calorific value of CNG is lower than LNG, and transportation is more expensive than LNG. Its transportation is also highly dangerous because of the high pressure. According to ARGUS Bulgarian’s Market Analysis, LNG will take the place of CNG. Also, the most feasible way to import LNG to the Balkans is BOTAS’ Marmara Eregli LNG terminal. Planned imports will start with 2,000 mt and will increase to 76,000 mt in five years. This will create an advantage for Bulgaria in diversifying its energy sources, reducing imports of Russian pipeline gas, and building leverage in negotiations with Gazprom. LNG will be effectively competing with an oil product like gasoil, gasoline, LPG, and fuel oil and will start to be used in heavy trucks in EU countries. These reasons will also increase demand more than forecasts. Turkey will supply Balkan countries, and transit LNG sales will increase the strategic importance of LNG (Argus, 2014).

CHAPTER 3

NATURAL GAS MARKET FUTURE FORECAST AND NECESSARY STORAGE CAPACITY

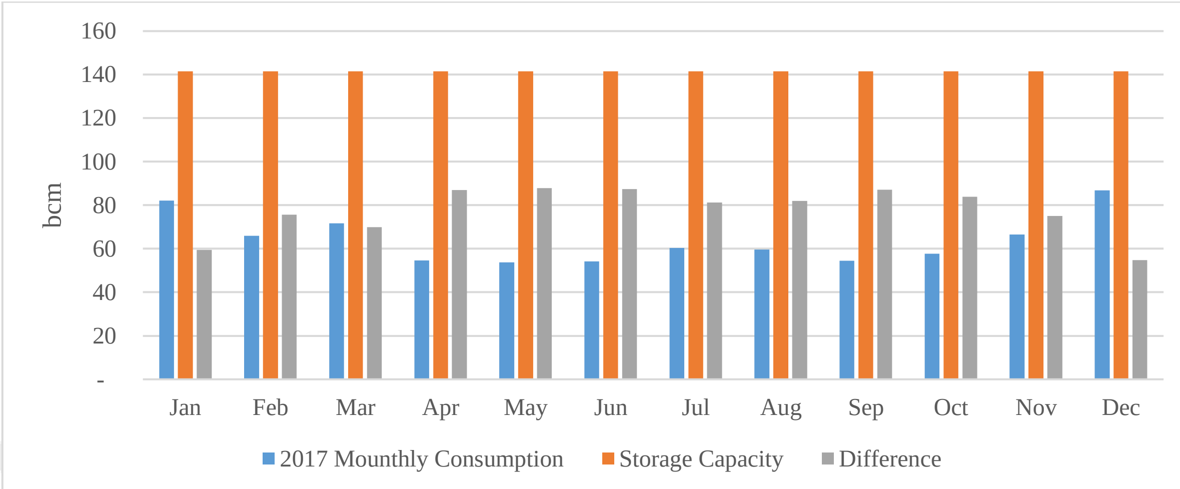
The Turkish natural gas market has developed every year and supply security is getting more important. For securing natural gas supply, Turkey has to have sufficient storage capacity. Turkey has 3.2 bcm of underground storage and 0.943 bcm of LNG storage capacity. Figure 4.1 shows Turkey's 2017 seasonal natural gas consumption, storage capacity, and the difference between consumption and storage. According to the figure, Turkey has a shortage between storage capacity and consumption mainly in high season, which creates risk to continuous supply.



Firgrure 3.1 Turkey's seasonal consumption and storage capacity

Source : EMRA,2017

On the other hand, if we analyze US storage and seasonal comsumption, it gives a perfect example of consumption and storage capacity balance. Figure 4.2 show 2017 US seasonal gas consumption, storage capacity and the difference between consumption and storage. The storage capacity is 72% higher than consumption, which proves that the United States has a sufficient amount of natural gas during the two months of high demand.



Figrure 3.2: US' seasonal consumption and storage capacity

Source: IEA,2018

According to this information, Turkey has to increase its storage capacity. It should also analyze the growth rate of the gas market to better understand the importance of the market share of natural gas resources (pipe gas and LNG). Turkey should plan on making future investments in storage to secure its supply.

Figure 4.3, using linear regression analysis, shows that Turkey's natural gas imports rose from 1986 to 2017 and will conitnue to rise.

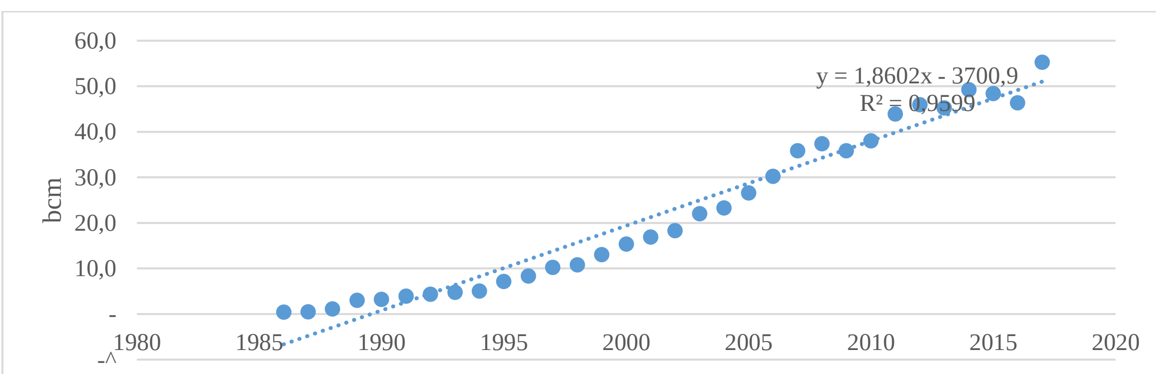


Figure 3.3: Turkish natural gas including pipegas and LNG import with linear regression analysis.

Source: BP, 2018

This data predicts that total imports will rise to 93.8 bcm by 2040 and that Turkey will demand extra resources in the near future. Also, long-term contracts for 12 bcm of gas are going to expire in 2021, and this amount has to be replaced with either LNG or pipeline gas.

In this study, three scenarios were created for the future LNG supply: a pessimistic scenario, a realistic scenario, and an optimistic scenario. These scenarios prepared according to the world LNG trade changes. Following figure 3.4 explain world LNG Trade and these capacity increase around 5% for every year. For this reason , 5% increase is the our realistic scenario. -3% of the realistic scenario is my pessimistic scenario and +3% of the realistic scenario is my opptimistic scenario. According to regressin data analyses with 95 % confidence interval, standart error has been determined to 15,66 and range of fallibility is ±1,96*15,66.

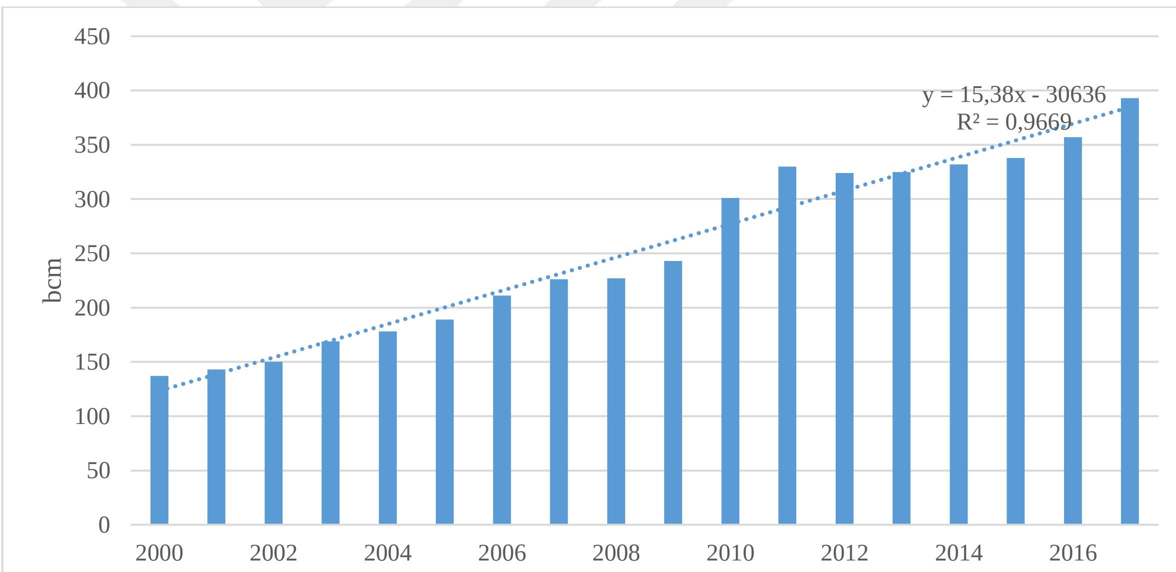


Figure 3.4: World LNG trade forecast linear regression

Source: Statista, 2019

The pessimistic scenario is that Turkey will sign a new long-term contract for natural gas supply via pipeline and under these circumstances Turkey will not increase LNG usage more than 21%. The reason for limiting LNG sources is that pipeline gas prices might be lower and using pipeline gas might established long-term relationships with regional neighbors. Beside that, new pipelines may open, such as TurkStream, Turkmenistan gas, the East-West

Gas Corridor, and the Eastern Mediterneam gas pipeline, which start to supply the Turkish market. In this case, LNG usage increases 2% every year, as seen in the following figure.

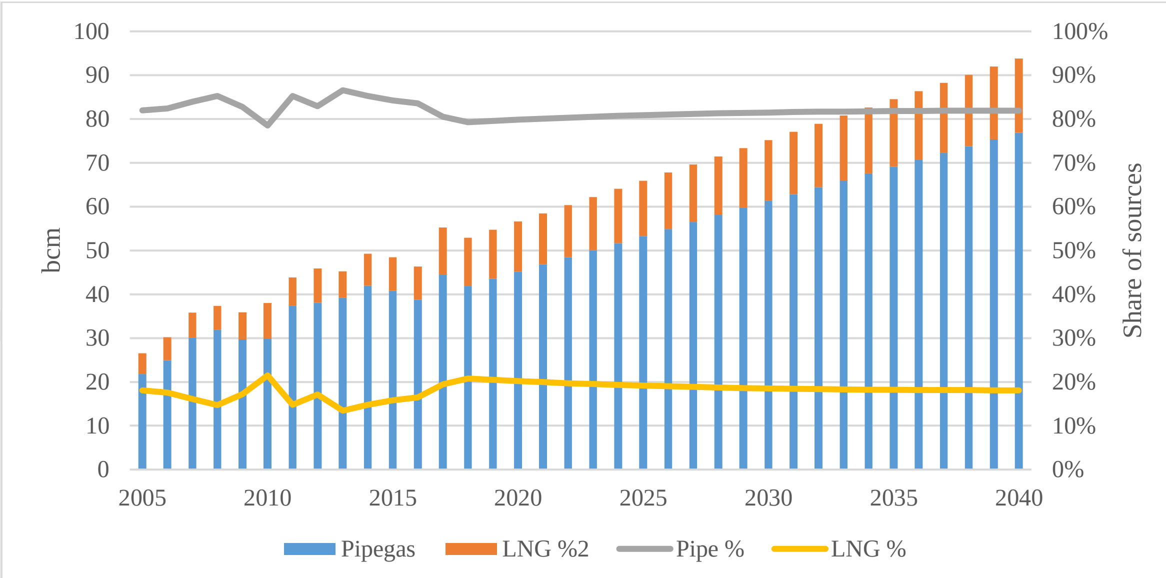


Figure 3.5: LNG consumption forecast linear increasement 2%

Source: EMRA,2017

In the anlysis of seasonable consumption between 2013-2017, the maximum consumption occured in December and the average consumption was 11% of the total consumption.

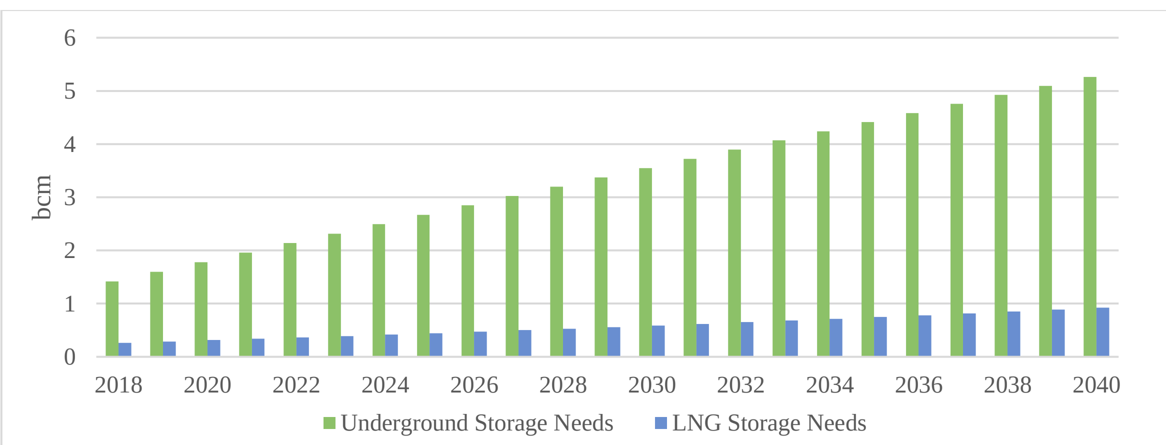


Figure 3.6: Minimum necessary storage needs for 2% linear increase

Sources: EMRA, 2017

According to this analysis, Turkey has to increase its underground storage capacity by 6% and LNG storage capacity by 5% every year with new investments if it is to secure one month of supply in the upcoming years.

In the realistic scenario, Turkey will follow world trends in the LNG trade and, at the same time, sign a new long-term contract for natural gas supply via pipeline, thus making gas investment offshore and onshore. Under these circumstances, Turkey will increase LNG usage every year, and in 2040 LNG reaches 35% of consumption. This strategy aims to decrease LNG prices and provide better and more operational flexibility to the LNG bussiness. On the other hand, new pipelines open, such as TurkStream, and the some contracts are extended. In this situation, LNG usage will increase 5% every year.

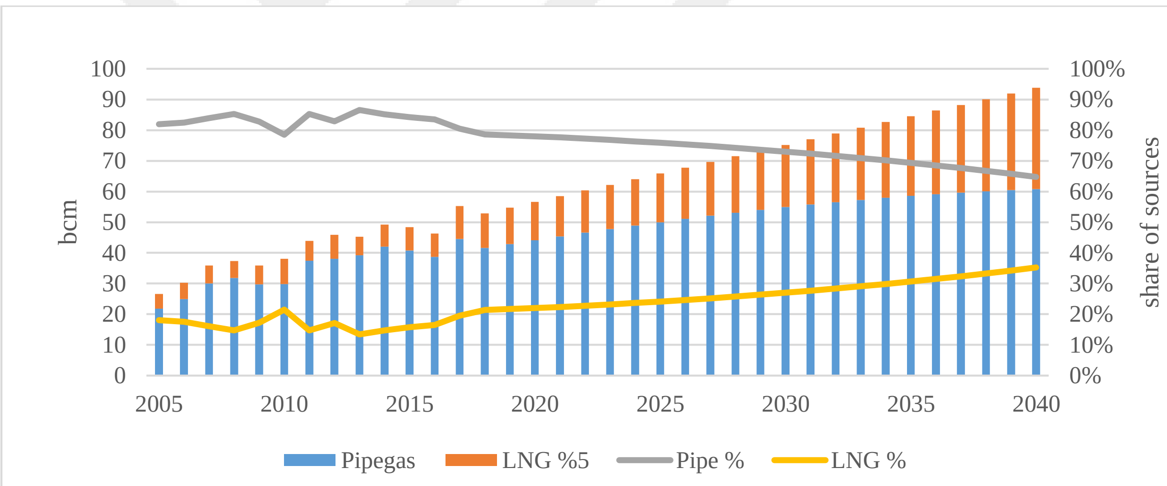


Figure 3.7: LNG consumption forecast linear increasement 5%

Sources: EMRA, 2017

According to this forecast, as well as previous monthly seasonable consumption anlysis, Figure 4.8 show the minimum necessary storage requirements to be able to provide one month of supply. Underground gas storage investment will need to be 4% and LNG storage investments will need to be 10%. In this scenario, Turkey contributes to its own source and country diversification.

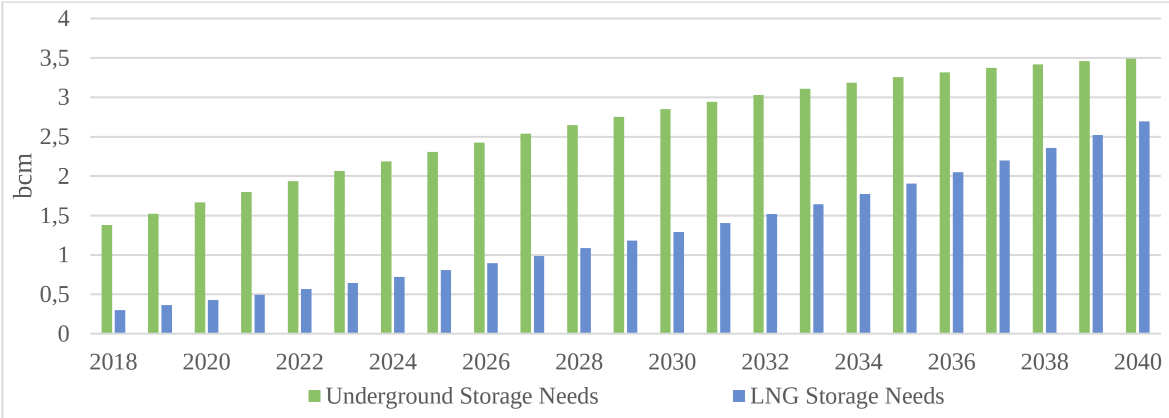


Figure 3.8: Minimum necessary storage needs for 5% linear increase

Sources: EMRA, 2017

In the optimistic sceneraio, Turkey replaces all of expiring contracts and increases its gas intake with LNG. New LNG investment will be made both offshore and onshore. The market will be completely transperent, and all supplies will be purchased from the spot market or through medium-term contracts, not long-term contracts. Under these circumstances, Turkey's LNG usage increases every year by 8% until 2040, when LNG becomes 54% of Turkey's total gas imports. This strategy aims to attract lower LNG prices due to a supply surplus and governmental energy strategy changes.

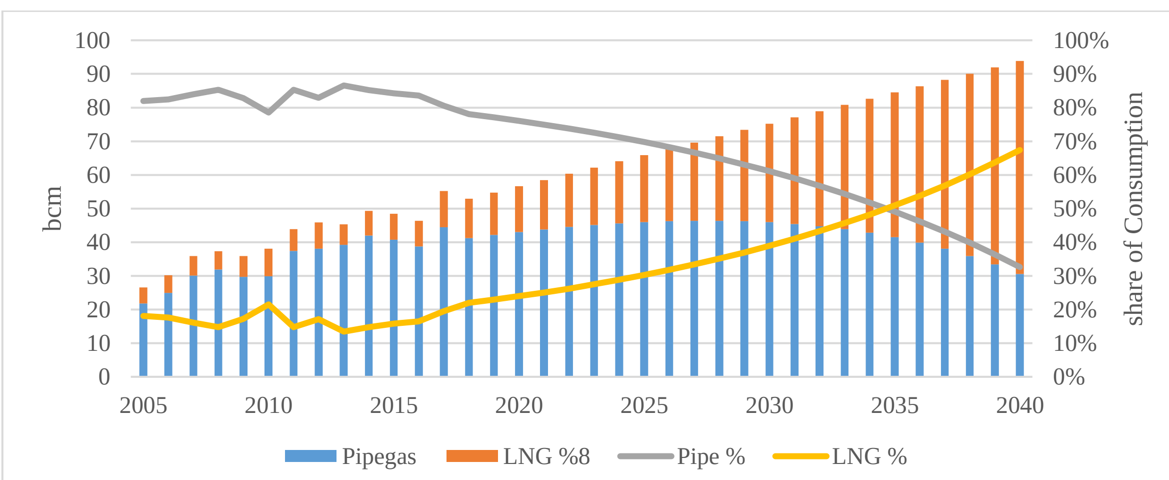


Figure 3.9: LNG consumption forecast linear increasement 8%

Sources: EMRA, 2017

In 2035, LNG's share of total gas imports will be higher than pipeline gas. This type of scenario will provide gas-supply security because regasification capacity will be higher and the LNG spot market can provide competitive prices. Storage capacity is highly important for this strategy to succeed. Figure 4.10 explains how underground storage capacity should increase 3% every year, reaching a sufficient level by 2028. However, LNG storage investment should increse 14% every year to secure monthly gas supplies.

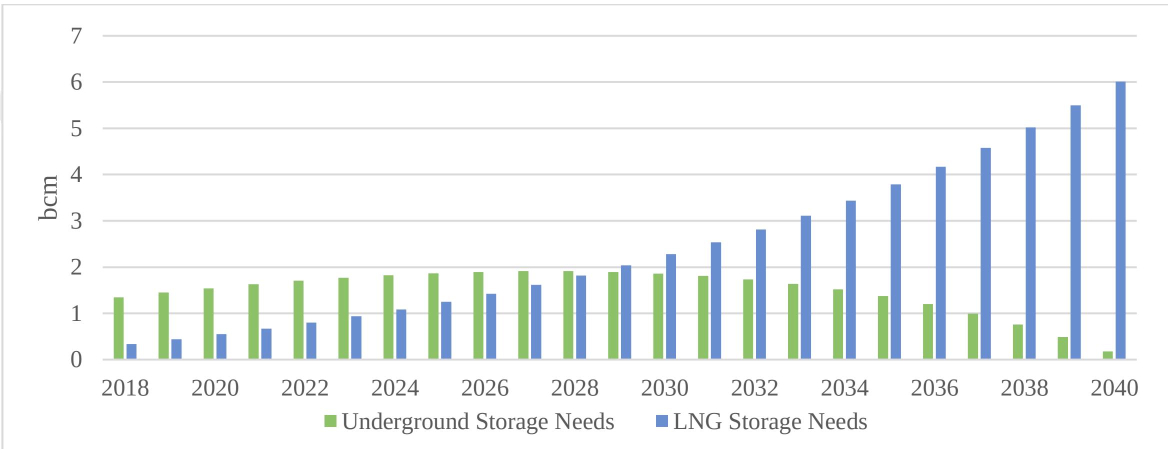


Figure 3.10: Minimum Necessary storage Needs for 8% linear increase

Sources: EMRA, 2017

Ultimately, this analysis reveals that the realistic forecast is the most optimal solution. LNG prices are already higher than pipeline gas prices, and the Turkish government continues to negotiate for new long-term pipeline contracts. However, Turkey has to diversify its supply sources. According to this information, LNG is the best alternative source and the market share of LNG increases to 30-35% of total natural gas imports. At the same time, Turkey is remains located between producer and consumer countries and may purchase natural gas at very low prices via pipeline. It will not be possible to use LNG more than pipeline gas in this scenario.

CONCLUSION AND RECOMMENDATION

In this thesis, the world LNG trade and usage are evaluate in two parts. LNG trade has not been as widely used as pipeline gas due to technological limitations. However, the share of LNG in total consumption is increasing annually because of technological development and the U.S. shale gas revolution, which turned the United States into a net-exporter of gas, rather than a net-importer. U.S. exports are increasing annually and they are targeted for the European and Asian markets. The major weakness of U.S. LNG is that it is further away from these markets, which adds higher transport costs. Nevertheless, investment in liquefaction capacity around the world is growing. Shale gas is found outside of the United States as well. Australia is using this technology to produce major volumes of gas, and other countries could do so in the future.

These developments will change the market and shape Turkish gas-supply strategy. Turkey has increased its regasification and storage capacity in recent years and is planning more investments for the future. According to the future forecast and the storage investment analyses LNG is not the major gas source for Turkey, but it is crucial component of its gas-supply security. If Turkey will increase usage of LNG as like as World LNG trade increase. LNG usage will be 35% of the total natural gas consumption. It is an alternative fuel for supply and decreases source and country dependency. Because LNG can arrive from any gas-producing country thanks to the spot market, it is flexible and will help secure demand. Turkey should increase storage capacity for security of the system and LNG storage capacity should increase 10% every year and Turkey has to put this investments to its future plan.

In addition, LNG will create new opportunities. For instance, being an LNG hub without LNG is impossible because source and country diversification is critical for hubs. LNG can also secure petrochemical production facilities feedstock, and LNG bunkering is new market that should took root in Turkey. Moreover, LNG is starting to be used as a fuel for heavy-duty trucks, and Turkey, thanks to its geographic advantages, can export LNG to Balkan countries, which need supply. All of these opportunities will increase the importance of LNG for Turkey.

To summarize, LNG is important to Turkish natural gas-supply security in the following cayhegories:

Economic

- Turkey has an adventagous location in the med region and re-exports LNG all around the world, to anywhere with a regasification terminal;
- It is a tradeable commodity like oil products and can be re-exported; and Turkey can store more LNG than its consumption and create LNG hub in the region
- Spot LNG exports create new LNG exporters besides BOTAS and, in the process, create a more liberal market;
- LNG trade competition between countries creates advantageous prices for Turkey, and create possibility to negotiate new, more favorable long-term contracts;
- LNG's maintenance costs are lower than pipe gas and CNG systems;
- Recently, LNG seems to be taking the place of the CNG markets that emerged from the lack of substructure in the Balkans, and Turkey can re-export gas to these countries;

Environment

- LNG is cleaner than other fossil fuels and carries importance for a more sustainable and greener climate future;
- Carbon emissions should be reduced in order to meet the requirements of the agreement Paris COP21 and LNG is the quick solution to fulfill Turkish environmental responsibility
- LNG usage as truck fuel in Europe should be examined and should be scaled to Turkey. Also, this is substantial way to reduce carbon emissions.

Energy Security

- As an alternative source for Turkish energy supply and security, because of spot market advantageous
- LNG creates flexibility for transportation because it shrinks to a volume 600 times smaller than pipe gas and is therefore easier to store and it can be supply easily.
- In order to provide energy supply security, the amount of natural gas entrance and exit points should be increased and the system should be supported with FSRUs
- Globally spot LNG market decrease dependency to neighboring countries and secure market

Geostrategy

- Exports face fewer international barriers than gas pipelines
- Turkey sorrounded by the sea and it creates advantegous for FSRU vessels, it can be connected to the national system all coastal areas where gas is needed;
- LNG can be supplied to villages and production facilities without natural gas substructure. In this way, fossil fuel usage can be reduced;
- Turkey is treated as an international bridge connecting natural gas producing and consuming countries, but this alone will not assure that it becomes a gas hub. Therefore, diversity of sources and countries should be improved. LNG is a potential solution product in the short-term in this regard;
- Given Turkey's location, surrounded by sea on three sides, creates an opportunity for building a new LNG bunkering market as a result of IMO 2020 sulfur restrictions and Actions and investments should be made to increase LNG bunkering capability prior to 2020.

In conclusion, Turkish natural gas consumption will be increase in the next years. According to this increase and Turkey has to find new supply sources for securing market, also Turkey has to decrease dependency level to neighbor countries. Besides that, LNG usage and trade increasing all around the world and Turkey is the part of this trend. All my researches and analysis shows that Turkey will increase LNG usage and LNG gets more share in the total consumption of Turkey. LNG is highly important for Turkish natural gas market supply security and it would be more important.

In this study, I have analyzed and explained the LNG business and trade from many different aspects. According to this analysis, I have tried to explain LNG's commercial importance for Turkey. I also prepared mathematical models explaining the share of Turkey's natural gas consumption and storage on a yearly basis based on the limited data that I could gather. The market is managed by BOTAS, who refused to share this information due to its confidentiality and importance to Turkish national security. I would encourage others who work on this topic to prefer to do this study for more liberal market and analyze LNG usage in daily and detailed natural gas consumption data.

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*These reports are private and confidential, they will show the jury if it is necessary.

CURRICULUM VITAE

Personal Information

Name Surname	:Mehmet Batuhan ALKAN
Birth Place and Date	: Istanbul 23.10.1990

Education

Bachelor's Degree	: Kadir Has University Industrial Engineering 2008-2013
Post Graduate	: Energy and Sustainable Development 2017-2019
Languages	: English

Work Experience

Working Place and Date	:Delphi Automotive Intern 2011
	Arçelik Intern 2012
	List Food Services 2014-1015
	Transpet Petroleum and Energy 2015 - ...

Contacts

Mobile	: 0530 071 96 97
E-mail	: batuhanalkan@live.com