A Feasibility Study on Submarine Gas Pipeline Construction from Cyprus to Turkey and Egypt

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ABSTRACT

Natural gas is a clean, environmentally friendly and one of the most efficient sources of energy that has a significantly increasing demand worldwide. It has a very wide range of uses such as fueling the power generators and heating the buildings with very low levels of greenhouse gas emissions. Cyprus has luckily discovered natural gas reserves and is on the verge of extracting it. The volume of these reserves is more than the domestic demand and it enables the country to export it. The aim of this thesis is to estimate whether it is financially feasible to export the natural gas found in Cyprus to two closest potential markets, namely, Turkey and Egypt.

To attain a conclusion, the export price of natural gas through a gas pipeline to Turkey and Egypt is calculated separately and then compared with the import prices these countries are currently paying to buy natural gas from neighboring countries. The results under the base case scenario demonstrated that it is feasible to export the natural gas found in Cyprus to both Turkey and Egypt.

Also various sensitivity analyses in this thesis showed that the possible profit of Turkey and Egypt is different against the changes in the volume of natural gas to be extracted and the import prices. It is determined that there is a high level of risk in importing the gas through pipeline.

Keywords: Natural Gas, Pipeline, Export Price, Cyprus, Turkey, Egypt

ÖZ

Doğalgaz temiz ve çevre dostu olması nedeniyle dünya geleninde talebi artmakta olan verimli bir enerji kaynağıdır. Elektrik üretiminden ısınmaya kadar birçok kullanım alanı olan doğalgaz çok düşük sera gazı emisyonuna sahiptir. Kıbrıs adası çevresinde bulunan doğalgaz reservleri yakın gelecekte çıkarılıp kullanıma hazır hale gelecektir. Bulunan gaz miktarının Kıbrıs'ın ihtiyacının üzerinde olması ülke adına büyük bir şans olup ihracat gelirlerini artıracak bir gelişmedir. Bu tezin amacı doğalgazın en yakın iki ülke konumundaki Türkiye ve Mısar'a boru hatları ile ihraç edilmesinin fizibil olup olmadığını hesaplamaktır.

Sonuca ulaşabilmek için her iki ülkeye de boru hatları ile ihraç edilmesi planlanan gazın maliyeti ve bu ülkelerin doğalgaz ithalatı için bugün farklı ülkelere ödemekte oldukları rakamlar hesaplanıp karşılaştırılmıştır. Gerçekleşmesi muhtemel değişkenlerle yapılan analiz sonucunda boru hattı ile doğalgazın Türkiye ve Mısar'a ihraç edilmesi hem Kıbrıs'ın hem de ithalatçı ülkelerin bu ticaretten karlı çıkacağını göstermektedir.

Ayrıca bu tezde yapılan hassaslık test sonuçları Türkiye ve Mısır'ın Kıbrıs'tan ithal edecekleri doğalgazdan yapmaları muhtemel karın çıkarılacak gaz miktarındaki ve ithal fiyatlarındaki değişikliklere karşı çok değişken olduğu ve bu sebepten dolayı da boru hattı ile doğalgazın ithal edilmesi projesinin ciddi riskler içerdiği tespit edilmiştir.

Anahtar Kelimeler: Doğalgaz, Boru Hattı, Ihracat Fiyatı, Kıbrıs, Türkiye, Mısır

To My Parents

ACKNOWLEDGMENT

I would like to thank Asst. Prof. Dr. Hasan Ulaş Altıok for his continuous support and guidance in the preparation of this study. Without his invaluable supervision, all my efforts could have been short-sighted.

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Last but not the least; I would like to appreciate my parents who supported me spiritually throughout my life.

I owe quite a lot to my family who allowed me to travel all the way from Iran to Cyprus and supported me all throughout my studies. I would like to dedicate this study to them as an indication of their significance in this study as well as in my life.

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LIST OF SYMBOLS AND ABBREVIATIONS

Bbl	Barrels
Bcf	Billion cubic feet
LNG	Liquid Natural Gas
M	1000 Units
Mcm	Thousand cubic meter
MMBtu	Million British thermal unit
MM	1,000,000 Units
MMcm	Million cubic meter
NG	Natural Gas
R.O.W	Right Of Way
Tcf	Trillion Cubic Feet

Chapter 1

INTRODUCTION

1.1 General

Natural gas, as a cleaner fossil fuel has had a growing impact in global energy stake in recent years. Natural gas possesses numerous positive attributes such as its physiochemical properties and energy content, its huge global reserves, longer resources' life comparing with oil, and transportability from producing sources to all destinations around the world. These properties have made it an alternative fuel to be used in residential, commercial, transportation and industrial sectors and a suitable primary energy for power plants. Projections by US Energy Information Administration (EIA) and International Energy Agency (IEA) predict that natural gas will experience the highest growth rate of demand until 2035 among fossil fuels. Furthermore, diversified options in natural gas deals, including long term and short-term agreements as well as spot contracts of LNG (Liquefied Natural Gas), has played an important role in the improvement of natural gas position in energy markets in both regional and international levels. This increasing flexibility has been vitally important for energy consuming countries. New resources have been discovered and led to increase the sources rapidly. Therefore, it is necessary for any potential owner to research the best potential market for it. On the other hand, the demand for energy is increasing rapidly as countries are trying to keep their growth rate.

It can be said that Cyprus' access to the gas sources for the residents and the neighboring countries will bring big status changes.

1.2 Thesis Objective

The aim of this study is to determine the most favorable target countries to transact the natural gas from Cyprus as a new owner of this natural resource. For the purpose of this research, the investigation has been done by a feasibility study on Turkey and Egypt.

1.3 Thesis Organization

Chapter 2 explains the Natural gas situation in the world, Cyprus, Turkey and Egypt and also further information about gas reserves, demand and production in the case of countries discussed in this study.

Chapter 3 explains the Gas Pipeline Type and further information about submarine pipeline as well as presented the Input Data that is used in the Analysis.

Chapter 4 focuses on Export Price of Natural Gas from Cyprus to Turkey and shows the Saving Price reaction in the face of change on variables by one way and two-way sensitivity analysis.

Chapter 5 focuses on Export Price of Natural Gas from Cyprus to Egypt and shows the Saving Price reaction in the face of change on variables by one way and two-way sensitivity analysis.

In Chapter 6, Conclusion and recommendations were explained.

Chapter 2

AN OVERVIEW OF NATURAL GAS IN CYPRUS, TURKEY AND EGYPT

2.1 Natural Gas

Natural gas is a kind of fossil fuel that is made when dried animal and plant are exposed to strong heat and pressure for more than 1000 years. In principle, the energy, which is deposited in the carcasses of animals and plants normally, comes from the sun that stores the carbon in the NG. However, it can be said that this is a gift from of the nature and if there is a chance, it will be repeated at least one thousand years later, so it is a non-renewable resource on a human time frame. Additionally, in terms of environmental and economic benefits, Natural gas is a healthy energy alternative with great importance.

However, access to the natural gas source has a direct effect on economy. Therefore, the transfer process of this energy and finding the suitable market for it is a hot subject in the world. Three countries are being discussed in this perusal: Cyprus as an owner of Hydrocarbon's resource, Turkey as lord of a good market for the NG transaction, and Egypt as the last state. It should be mentioned that due to the significant reduction in natural gas supplies and an increase in domestic demand, the need to import the gas to Egypt is increasing. Accordingly, these targets could be good markets for Cyprus Natural gas.

2.1.1 The Natural Gas Demand and Consumption in the World

The natural gas among other fossil fuel such as coal has fast growing market in the world. It is expected the Natural gas consumption will have a significant increase from 2010 to 2040 and also the gas consumption will be changed from 113.0 Tcf to 185.0 Tcf in coming 30 years (EIA-0484, 2013).

In comparison to coal and oil, Natural gas has a lower carbon ratio. Thus, it is a favorable fossil fuel in terms of environmental view as well as lower capital cost in generating the desirable heat rates. Therefore, the fuel for power plants (EIA-0484, 2013) is taken into consideration by the governments. The natural gas demand by the world is presented in Figure 2.1.

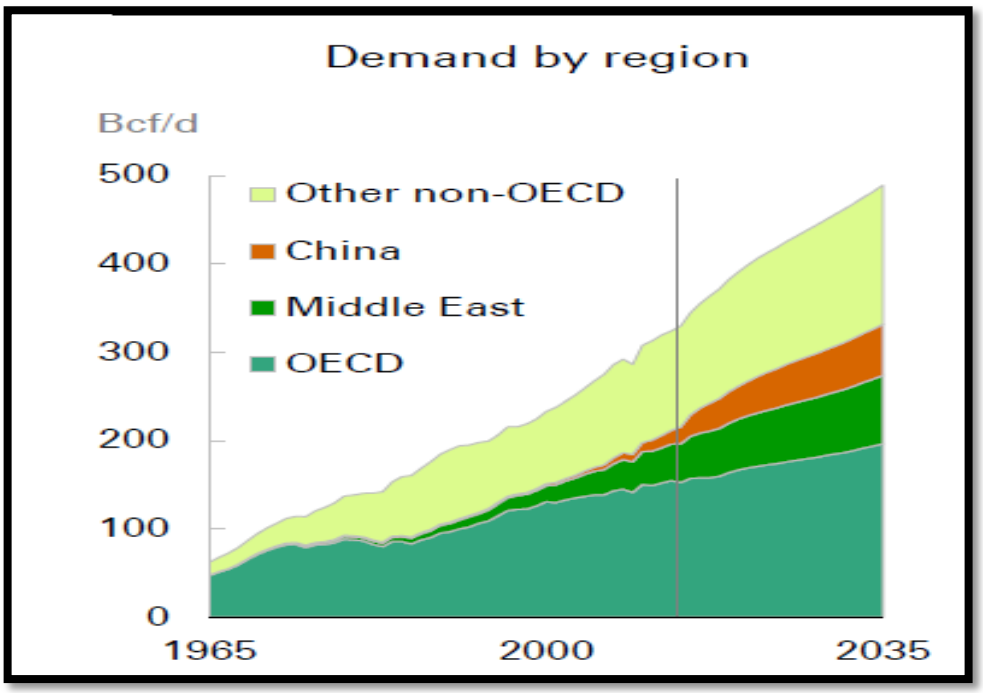

Figure 2.1 : The Worldwide Demand for Natural Gas by Region

According to the Figure 2.1, much of the growth in natural gas consumption belongs to the non-OECD countries that are not a member of the Organization for Economic

Cooperation and Development and they have around 90 percent growing in natural gas consumption. This is if the members of OECD countries have 17 percent increase until 2035 (EIA-0484, 2013).

2.1.2 The Usage by Sectors

According to the Energy Outlook 2035, more than 80 percent of total growing in demand happened because of the increasing consumption by the segments such as power plants and industrial sector. The worldwide growing rate of Natural gas consumption by power is expected to be 75 billion cubic feet per day, that is approximately 2.3 percent per year and the growing usage of industry of this energy is around 61 billion cubic feet / day followed by 1.8 percent annually grew by 2035. With the additional demand of Natural gas by power plants and industrial sector together will be 50 billion cubic feet per day in the non OECD as well as the growth in power plant and industrial segment is around 25 and 12 billion cubic feet per day in the OECD countries. The fastest-growing segment is the transportation industry that will be 3 percent of total Natural gas consumption until 2035 (BP-p.l.c., 2015). Figure 2.2 illustrates the percent usage of the total worldwide consumption of natural gas in different sectors by the end of 2012.

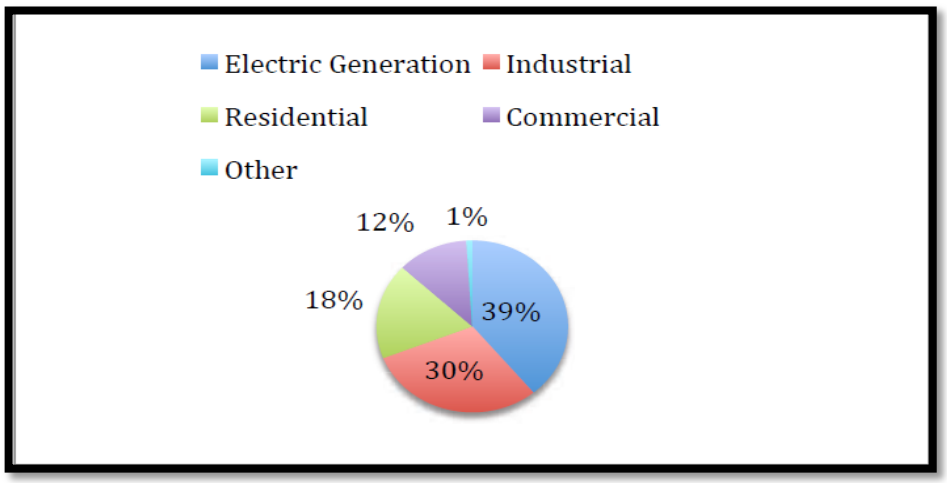

Figure 2.2: World Natural Gas Consumption by Sectors at 2012

According to the Figure 2.2, the power plants are the first and industrial sectors are the second biggest consumers of the Natural gas in the world.

2.1.3 Natural Gas Proved Reserves

According to the Statistical Review of World Energy around 185.7 Trillion cubic meters of Natural gas proved reserves are available in the world at the end of 2013 (BP-statistical, 2014).

Table 2.1: Natural gas proved Reserves, Geologically

Natural Gas Proved Reserves					
Location	At end of 1993	At end of 2003	At end of 2012	At end of 2013	Share of Total
Total North America	8.8	7.4	11.1	11.7	6.30%
Total S. & Cent. America	5.4	6.8	7.7	7.7	4.10%
Total Europe & Eurasia	40.5	42.7	56.5	56.6	30.50%
Total Middle East	44.4	72.2	80.3	80.3	43.20%
Total Africa	10	13.9	14.5	14.2	7.60%
Total Asia Pacific	9.3	12.7	15.2	15.2	8.20%
Total World	**118.4**	**155.7**	**185.3**	**185.7**	**100%**
Iran	20.7	27.6	33.6	33.8	18.20%
Russian Federation	n/a	30.4	31	31.3	16.80%
Qatar	7.1	25.3	24.9	24.7	13.30%
* The unit of measurement is Trillion cubic meteres or Tcm					

Table 2.1 shows the amount of gas reserves from 1993 to end of 2013. With regard to the above table, the amount of gas reserves in the world grew by almost 57% in last 20 years. The participations of any region of the Natural gas proved reserves in the world are presented in the last bar. The Middle East has the largest share among other regions. The largest ranked gas reserves in the world at the end of 2013 were respectively Iran, Russia and Qatar (BP-statistical, 2014).

Given that the value of gas reserves in Cyprus are still not disclosed so the exact amount of the country's share of world proven gas reserves is not possible.

2.2 The Natural Gas in Cyprus

The first hydrocarbon identification in Cyprus was carried out by the Iraq Petroleum company since 1938 until 1948 while conducting the geophysical and geological study on the island. Then during the period 1949-1970, four wells were discovered at depths between 1,250-3,295 m on the coast but after drilling through the local company the four wells determined by the Forest Oil Corporation in Tseri, Moni, Archangelos and Lefkoniko areas were dry holes.

Since 1970, surveys on offshore and shallow waters up to 200 m started by different companies and institutes such as Delta Exploration Inc., Sefel Geophysical Ltd of Canada and the Soviet Academy of Scientists (Demetriou, 2013).

2.2.1 The Aphrodite Gas Discovery

The state of the Republic of Cyprus employed the company of Norwegian (PGS) in the early 2000s for primary investigates to determine Cyprus's hydrocarbon potential through seismic surveys, and in the other words, to specify if this place is worthwhile to follow a much more costly heuristic drilling, The company results evidence was very favorable that The Cyprus government made a tender for exploration and production licenses for eleven offshore blocks in February 2007. For as much as just 3 medium size companies participated in the bid so they granted a license to medium company of the United States, Nobel Energy, in October 2008. However, the Novel Energy drilled its first exploratory in Block 12 at September 2011 and the result of this operation displayed 5-8 Trillion cubic feet or Tcf natural gas deposit in deep water of about 1,700 meters. It should be mentioned that later on December 2013, new data was announced by the Israeli company, Delek Drilling and Anver Oil Exploration, which claimed that the amounts of Natural gas in Block 12 via

estimation is around 4.1 Tcf,; equals to 0.063% of global conventional reserves (Reuters, 2013) and in January 2014 the amount of possible and recoverable reserves was decreased to 3.1 Tcf by Nobel Energy (Cyprus-Mail, 2014).

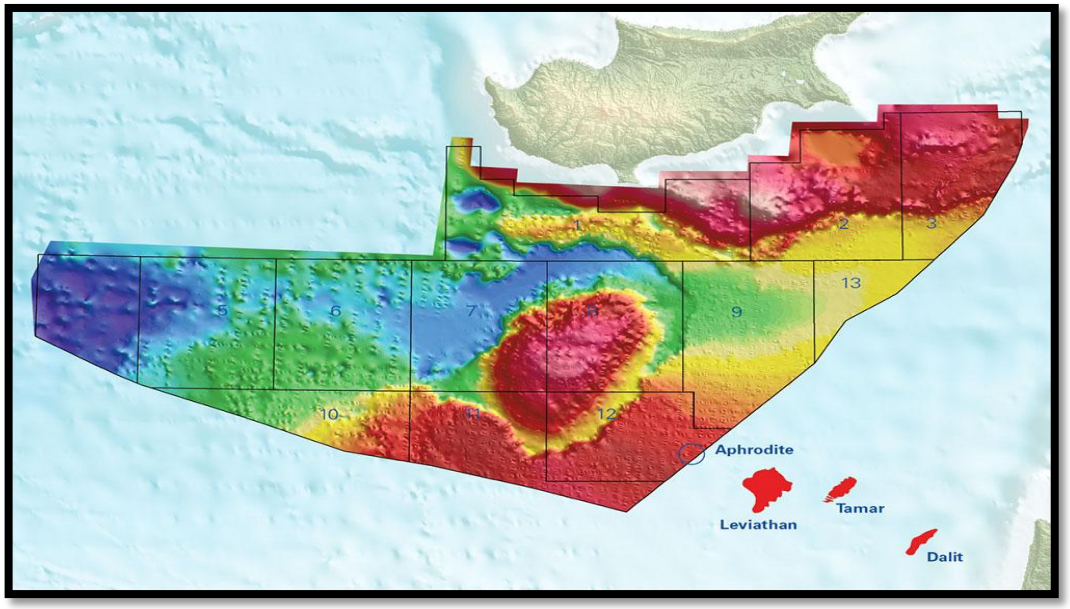

Figure 2.3: The Exclusive Economic Zone in Cyprus

The Exclusive Economic Zone of Cyprus covers an area about 51 thousand km and also classified to 13 offshore blocks. In the first season of 2013 the second drilling licenses around Cyprus was awarded for 5 offshore blocks, including Blocks 2,3,9 to the Italian major ENI Company and the world's largest LNG buyer, Korean utility KOGAS and Blocks 10, 11 were awarded to the French Major Total as it can be seen in Figure 2.4.

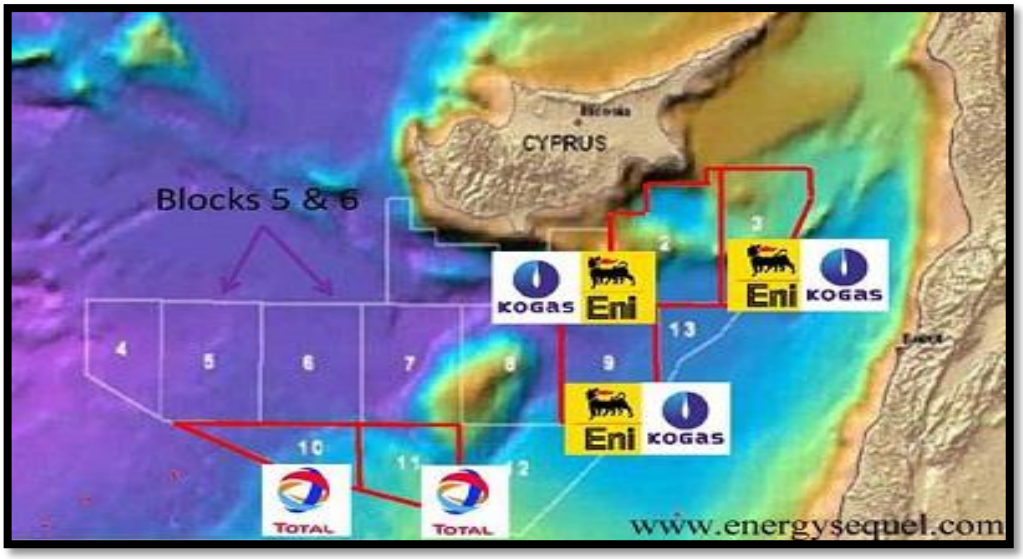

Figure 2.4: The Offshore Blocks which is awarded in the Second Licenses Round

The primary study representing Block 9 is considered to have the biggest potential between other blocks in Cyprus. Substantially, two times higher than the capacity of gas discovered in Aphrodite (Giamouridis, 2013).

The Levant basin geographically is at the east of the Mediterranean. The Levant basin is shared between a few countries at the Eastern Mediterranean. i.e. Cyprus, Israel, Palestine, Lebanon, Syria and Turkey. This is represented in Figure 2.5.

Figure 2.5: Levant Basin Geographical Location

According to the U.S. Geological Survey and U.S Energy Information Administration (EIA) the Levant Basin have deposit of oil around 1.7 billion barrels and also 122 Tcf of NG (USGS, 2010). Therefore, it can affect the amount of natural gas that will be explored in Cyprus.

Cyprus is the third biggest island in the Mediterranean and it has a strategic location. It is located close to Africa, Middle East and Europe and this is definitely an advantage in accessing to bigger market options. Additionally, this discovery will be too important for the entire Cyprus (if the problems will be solved between two sides). It will become independent in the Natural Gas, beside, it can appear as an exporter in the market. This export will produce income and increment in the Gross NP that will lead to the warranty of stability in the country against financial crises. In a primary report, which provided by MI Technology (Massachusetts Institute of Technology), forecasted that unexpectedly if all the industries in Cyprus get converted to gas, it will have adequate access to Natural resources for export to international markets (Institute, 2013).

The capacity of early exploration in Cyprus is currently at 3.1 Tcf but there is some ongoing explorations and also all the 13 blocks have not been discovered yet, so this number is expected to show a great increase. However, the export option can be beneficial if it is supported by intelligent decisions.

2.2.2 The Natural Gas Demand in Cyprus

The EIA report shows that around 60 thousand barrels of oil are exported to the South Cyprus per day (EIA, 2012). It should be mentioned that each barrel oil is equal to 6000 cubic feet of natural gas (Investopedia, 2015). Therefore, as regards to the population distribution rate on both sides which is around 75% in the South and ~

25% in North Cyprus, it can be estimated that the approximate gas consumption in the region is around 80000 barrels oil per day which is equal to 480 million cubic feet per day of the natural gas.

However, for providing a report with the precise demand rate of this energy in Cyprus, it is necessary to consider two important factors; first is identifying that how much of the economy will be converted to gas or become gas dependent, and the second is the possibility of the unification the Cyprus which will be reasonably and directly have an impact on expenditures as well as the demand.

However, exploration is the first step of the discovery. The important sector from the discovery's options is the exploitation possibilities. The subject matter is how to link these natural resources to markets. There is a set of solutions' options including: Pipeline, LNG (Liquefied Natural Gas), CNG (Compressed Natural Gas) and GTW (Gas To Wire).

The Pipelines are critically important due to the high security in terms of transporting the dangerous substances and the ability to transport in high volume as well as the low cost of installation when compared to other gas transmission routes. Moreover, this study investigates the export of natural gas to Turkey and Egypt from Cyprus through submarine pipeline, regardless of the political problem, whether if it is favorable or not.

2.3 The Natural Gas in Turkey

Geographically, Turkey is known as a bridge between Europe and Middle East and also the vicinity with countries which have access to the natural resource converted it

into one of the most important markets for energy in the world (Figure 2.6). This potential has resulted in its faster and more tangible growth of economy in the world.

Figure 2.6: Overview of Turkey and the Neighboring Countries

Regarding to its location, Turkey has a significant duty in transmission of the natural gas. In order to supply Natural gas to the continental Europe, which is known as second- superlative market in the world because of the remarkable resources which are located in the Middle East and Caspian Basin, Turkey is the bridge between European and Middle East (INSS, 2014).

2.3.1 Production

The production of Natural Gas by Turkey is not very significant and according to the EIA the total gas that generated through this country in 2012 is around 22 Billion Cubic Feet (Bcf) or 623.23 Million Cubic Meter (MMcm) and this number in the report that has been provided by the Central Intelligent Agency for 2013 decreased to 537 MMcm (EIA-a, 2015). Turkey's estimated natural gas reserves in 2014 that was

provided by Oil and Gas Journal is about 241 Billion Cubic Feet or 6827.2 MMcm. Akcakoca, East Ayazli, Akkaya, and Ayazli are the proved resources of natural gas fields that are located in the Black Sea has been exploited by Turkey (Figure 2.7).

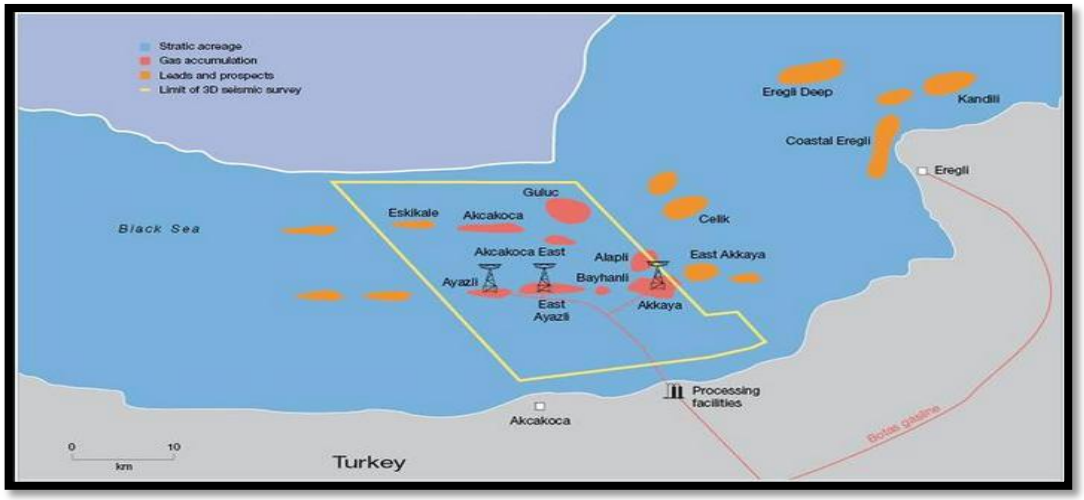

Figure 2.7: The Gas Fields in the Black Sea are exploited by Turkey

2.3.2 The Consumption and Import in Turkey

The production of gas in Turkey is too small in comparison to the rate of country consumption. As a result, there is an increasing dependence on imports. On the other hand, the domestic consumption of Natural Gas in Turkey has risen annually. Moreover, the electric power is the biggest domestic sector user of this natural energy. As it can be seen in Figure 2.8, the production is not enough to cover the rate of Turkey's usage of resources, so it can be said that just lying on the imports meet the domestic demand. The gap between the production with consumption plus export will be given the net import in each year.

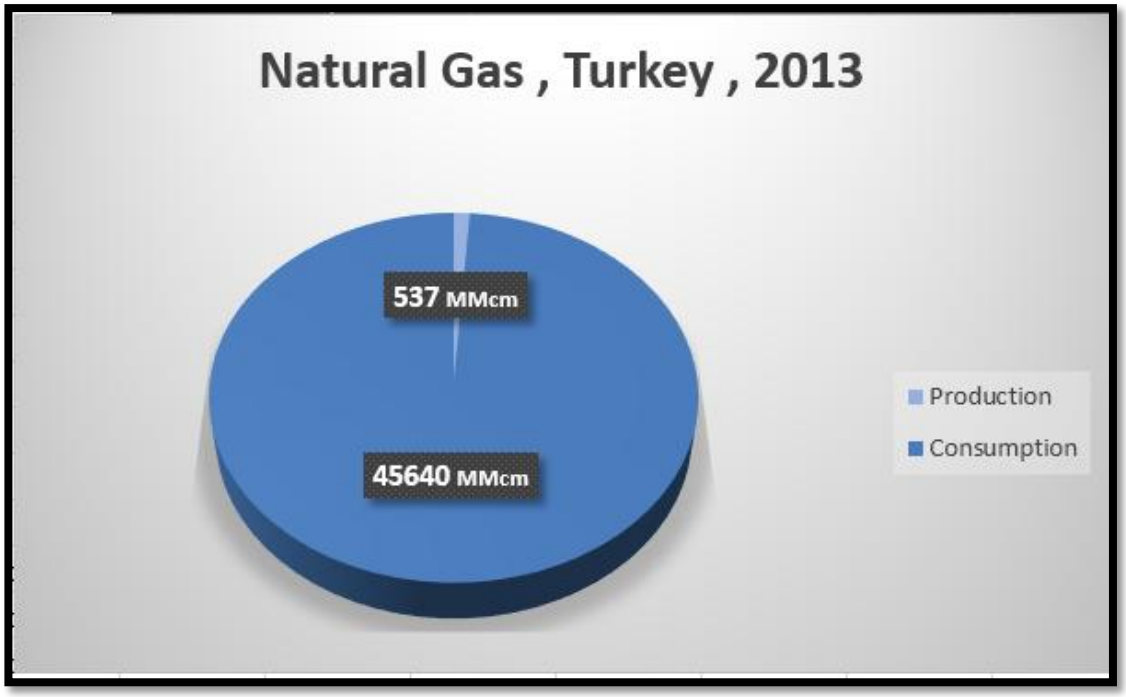

Figure 2.8: Consumption and Production of Natural Gas 2013 (EIA-a, 2015)

Pursuant to the report that has been published by the Central Intelligent Agency in 2013, the domestic consumption of Natural Gas is about 45.64 Bcm or 45640 MMcm, which has taken the rank 22 in the world. On the other hand, Turkey by importing 45.27 Bcm or 45270 MMcm has ranked 9 and also in export it is ranked 40 by 654 MMcm in 2013. According to the volume of consumption and production, the import has a vital role to meet the domestic demand in Turkey, 58% of sources that were exported to Turkey has been supplied by Russia and Iran with 19% of total is the second supplier of natural gas as presented in Figure 2.9. The other form of Gas (Liquid Gas) has been transferred from Algeria and Nigeria (INSS, 2014).

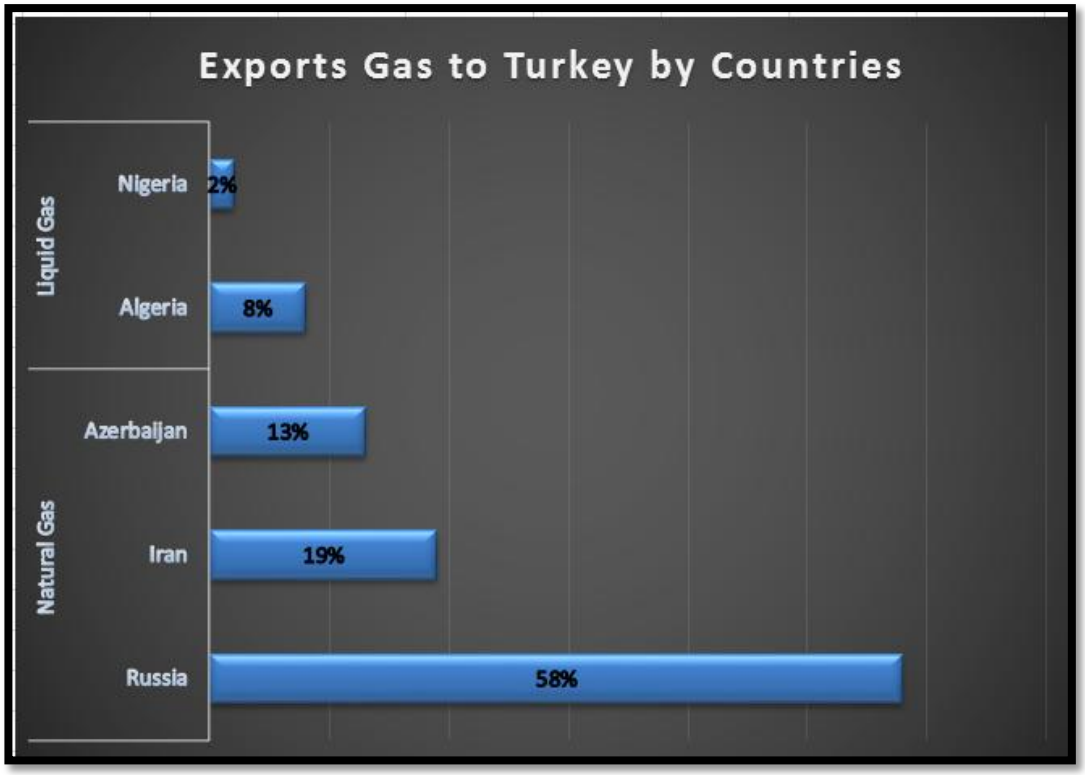

Figure 2.9: Percentage of Export Gas by Countries to Turkey 2013 (INSS, 2014)

BOTAŞ as a state owned company in the field of crude oil and natural gas pipelines in Turkey is the responsible for trading and also as a buyer it is known in the import contracts. However, five import gas agreements via pipeline in Turkey are available (Gazprom-Export, 2014):

A) In 2001 an agreement was signed between Turkey (BOTAŞ) and Russia to supply 8 Bcm annually gas via Bulgaria pipeline, it will be finished in 2021 and the length of the agreement is 20 years.

B) In 2002 an agreement was signed between Turkey (BOTAŞ) and Iran to supply 10.5 Bcm annual gas via Tabriz-Ankara pipeline (2577 km), it will be finished in 2025 and the length of the agreement is 23 years.

C) In 2003 an agreement was signed between Turkey (BOTAŞ) and Russia to supply 15 Bcm annually gas via Blue stream pipeline (1213 km), it will be finished in 2028 and the length of the agreement is 25 years.

D) In 2007 an agreement was signed between Turkey (BOTAŞ) and Azerbaijan to supply 6.5 Bcm annually gas via South Caucasus – Azerbaijan pipeline (691 km), it will be finished in 2022 and the length of the agreement is 15 years.

E) In 2012 an agreement was signed between Turkey (private companies) and Russia to supply 6 Bcm annually gas via western line pipeline, it will be finished in 2042 and the length of the agreement is 30 years.

In light of the significant increment in the rate of a country's use of resources the government seeks to find a new Gas seller, same are trying to connect with northern Iraq, which is the owner of 1.6 % of the total reserves in the world and Israel. There are also plans to expand the dependence with Iran and Azerbaijan. It should be noted that the annual capacity of transporting the Natural Gas by current pipeline between Iran and Ankara is about 16 Bcm, so there is a lower chance for both countries in order to develop the collaboration at this time. In addition, TANAP is a new pipeline from Azerbaijan – Georgia- Turkey to Europe with approximately 1841 km length and also it will be started in 2015 and expected to be ready in 2018. This pipeline is the new door in front of Turkey to increase the import from of the Caspian Sea through Azerbaijan and it helps the country to take place as a second importer to Turkey and the overtaking of Iran.

2.4 The Natural Gas in Egypt

Egypt is a country which is located among three continentals; Africa, Asia and Europe (Thus it is called Afro-Eurasia) with a population around 89,002,000 in 2015.

In the field of energy Egypt with 691,000 bbl/D production of oil was the biggest oil producer in 2013. It is not a member of OPEC, the Organization of the Petroleum Exporting Countries, and also generated 2,141.05 Tcf as the second biggest dry natural gas producer in Africa in 2013. However, Egypt is the biggest owner of oil refinery, which produces large amounts of oil in Africa continent (726,000 bbl/D 2012), and it has the biggest consumption with 20 percent of oil and 40 percent of dry natural gas consumption of the entire Africa (EIA-E, 2014). In terms of operation of the Suez Canal, which is the important way to export the Persian Gulf oil, and also Suez Mediterranean Pipeline to export LNG, Egypt has an important role. The natural gas situation in Egypt is as follow:

According to the official estimate of Egypt, natural gas proved reserves in 2014 that was provided by the Oil and Gas Journal, the country possesses around 2.18 trillion cubic meters. Regarding to the world fact book at the central Intelligent Agency, Egypt produced 53.63 billion cubic meters, around 53.8 Bcm for regional consumption and 3.823 Bcm export of Natural Gas in 2012. Although the amount of imported natural gas was zero until 2012, the unexpected increase in domestic consumption of Egypt has been attempted to respond to its' demand by importing from other countries in 2013.

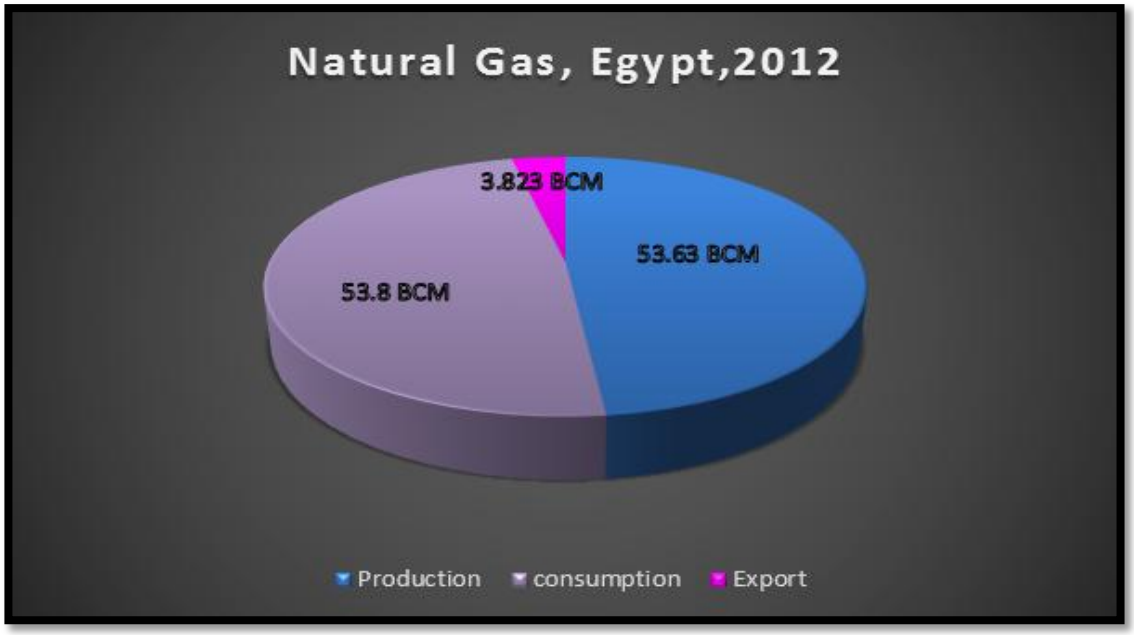

Figure 2.10: Natural Gas in Egypt at 2012 (EIA-E, 2014)

As shown in the pie chart above, it is indicated that the amount of production is approximately close to the amount of consumption. Therefore, the amount of Export value which shown in the graph and also the difference between the consumption and production values has been covered by the import of natural gas.

Egypt has LNG technology, but due to the increasing rate of domestic consumption and the significant decrease on Natural gas reserves, there isn't an adequate gas to use and export. The government is trying to find a new way to cover the domestic demand by new exploration in the Nile region via foreign company_and also is negotiating with Cyprus and Israel on the issue of gas imports (dailynewsegypt, 2015).

Chapter 3

INPUT DATA USED IN THE ANALYSIS

3.1 The Gas Pipeline Type

The pipeline is a kind of gas transportation system with two different models. The pipeline, which is constructed under or on the surface the earth, is the onshore pipeline. The second one is offshore pipeline, which is also known as subsea or submarine pipeline. In the latter case, all pipe or part of the system is floating in water. In general, any pipe that has been installed on the seabed or under the riverbed is called a submarine pipeline.

The pipeline is used to redeploy gas and liquids from source to destination. The nature of the material will have a direct impact on the pipeline's design and the installation method. The steel lines, collapsible plastic pipelines and composite pipes are different types of pipeline. Experience has been proven that the pipeline is a safe transport system for a vast range of substances from fresh water to dangerous materials consisting of crude oil, gas, waste water from the households and other type of fluid and gaseous elements across the oceans.

The pipeline route normally starts from the source to one or more than one destination. Therefore, it can be said that the pipeline operation is the same as the blood vessel, which takes the material from the source and distribute to destinations. However, the common pattern of the pipeline in order to transfer the hazardous

Liquid and gaseous is the steel line that will be used to transfer the natural gas from Cyprus to different destinations, which are Turkey and Egypt in this study.

The offshore steel pipeline, which is used for dangerous material, takes a role in this survey. Therefore, to make it more understandable, Installation methods are briefly described in this study.

The installation of the submarine gas pipeline requires a special set of equipping vessel which is generated for this job. There are two methods for offshore pipeline installation. The first method is to complete the pipe on the deck and then lay out on the seabed by moving vessel, which is shown in Figure 3.1.

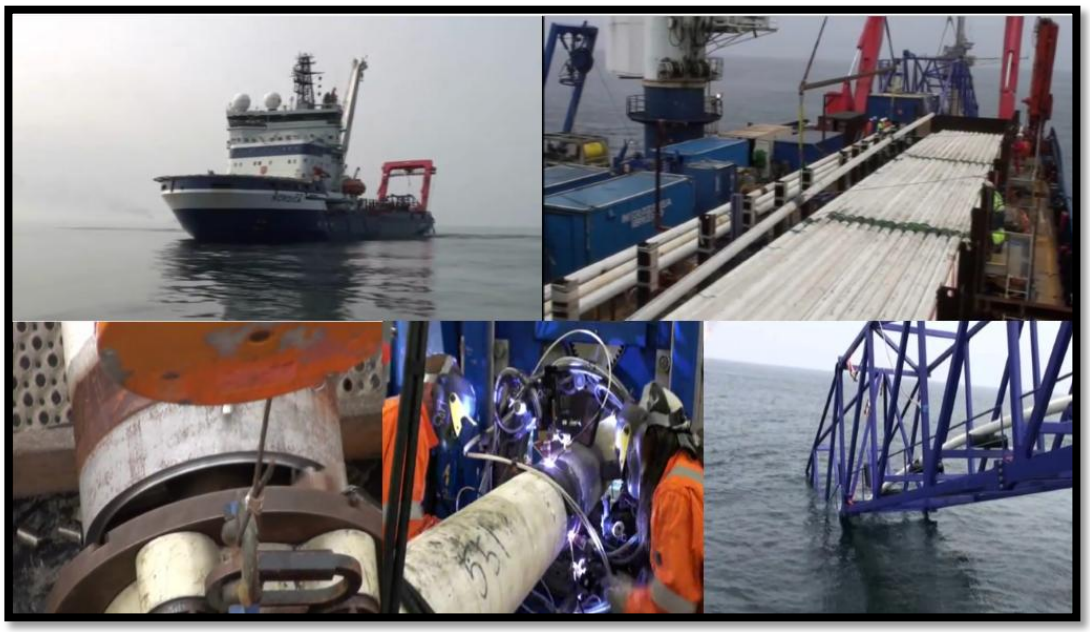

Figure 3.1: The Process of Installment and Laying the Pipeline on the Ship

Secondly, it is constructing the pipe on the plank before fitting it on the seabed and after the installation the pipes are carried by vessel in the sea. With regard to the

condition of pipe route, the pipe can be laid out on the surface and then buried in the seabed.

Figure 3.2: The Process of the Pipeline Installment on the Shore

As usual, the steel pipe has been used for deeper water and ordered to lay pipe on inshore or shallow location. The common type pipe is the composite variable that is smaller than the steel type and used for non-dangerous material such as fresh water. In addition, the entire line needs the same degree of surveillance and attention in their planning, testing, installing, maintenance and operations regardless of the offshore pipeline models.

3.1.1 Submarine Pipeline Characteristics

The offshore gas pipeline has two important factors consisting of diameter and stoutness. The submarine natural gas pipeline diameter starts from 76 millimeter or 3 inch, to 1,800 millimeter or 72 inch for wide capacity line. The stoutness of the pipe wall normally begins from 0.39 inches at the lowest level to 3 inches in the highest thickness (Gerwick, 2007). The diverse size of the diameter and the wall stoutness

help the pipeline designer to provide the best pipe models for transferring the fluids and gas with high pressure and temperature.

The pipeline diameter assumption in this study is 28 and 24 inch for offshore pipeline and 40 inch for onshore pipeline. The diameter size is taken from the report provided for submission to the authorities of Turkish Republic of Northern Cyprus (Pourbozorgi, 2014).

3.1.2 The Cost of Pipeline

The gas pipeline cost is divided into 4 categories consisting of material, labor, miscellaneous and the right of way. The material and labor are the most important parameters, that pervious factors are covered around 70%-80% of the total investment cost and also the surveying, engineering, supervision, allowances, overhead, and filling fees are the part of miscellaneous cost as well as the right of way or R.O.W is a term used to explain the legal right that is determined by the owner of location, specific route or property belonging to others in order to use, rent, buy or grant by another person or country. Regarding to the R.O.W definition, it can be zero, in one project, and it can have a significant percentage in another one.

Finally, in the gas pipeline construction process, some factors will be impacted on the cost such as the gas pipe diameter, location, rules and so on. In general, the cost per mile will be increased by increment of the pipe diameter, which means there is a direct relationship between the construction cost and the diameter of the pipeline. The capital cost will be increased if the pipeline is going to pass through the residential areas, highway or river roads. The labor and tax rules in each country are different and come from governments' politic and result to the project faced by fluctuating cost (SARI/EI, 2008).

3.2 Thesis Methodology

The methodology which has been used to determine the export natural gas price from Cyprus to the countries discussed in this study is as follows:

- Specified the pipeline construction cost and operating cost
- Determined the amount of Export gas per day and annual
- Calculated the present value of Exportable gas during the life of the project
- Divided the construction cost to the present value of total Exportable gas and determined the construction cost per unit
- Divided the annual operating cost to annual exportable gas in order to determined operating cost per unit
- Specified the unit cost price by adding construction and operating cost/ unit together
- Achieved to the export price by adding the Gas price at the wellhead
- Got the import price in Turkey and Egypt
- Calculated the saving in the project by comparing the export price from Cyprus and import gas price in Turkey and Egypt

3.3 General Input Data

In this section, the items which are going to be used to determine the total investment cost per unit are being described in the following table. These items consist of the methods for calculating the construction cost, construction period, and life of the project, discount rate and operating cost and so on. The summary of base case data is presented in Table 3.1.

Table 3.1: Summary of Base Case Input Data

Title		Number
Life of Project		15 Years
Discount Rate		12%
Course of Construction		3 Years
Operating Cost		5% Annual
Gas Price at Wellhead		$121.616 Mcm
Natural Gas Import Price in Turkey	Russian 58%	$418 Mcm
	Iran 19%	$487 Mcm
	Azerbaijan 13%	$340 Mcm
Natural Gas Import Price in Egypt	Israel	~$255.47Mcm
Investment Cost per length (km) /Diameter (inch)	Onshore pipe line	~ $85,960.73
	Offshore pipe line	~ $156,292.27
Pipeline Length /Km	Wellhead – Mersin	~295
	Wellhead – Ankara	~848
	Wellhead – Egypt	~180

3.3.1 The Construction Cost

The construction cost is very dependent on the location; therefore, the estimated cost of the pipelines is uncertain, because there is not a fixed formula or a way to determine the exact cost of gas pipeline constructions in each location and any situation at the present time.

Nathan Parker the member of Transportation Institute Studies in California has been presented a paper that shows the new formula or method to estimate the gas pipeline construction cost. In this report Nathan collected the construction cost to produce a passable estimate equation for pipeline construction cost (Parker, 2004). The result of

this method is less than the cost estimated in this study. The computation base of this method is presented in Appendix.

In order to determine the construction cost, the average estimated cost of three under construction projects in the Middle East and Asia has been used (Wikipedia, 2015), these projects, which consist of the TAPI, are between Turkmenistan and India via Afghanistan into Pakistan with 1735 km length (Alexander, 2006), IP that is between Iran and Pakistan with 2775 km length (XINHUA, 2008) and also TANAP will be connected the Azerbaijan to Europe through Turkey with 1841 km length (Hürriyet, 2015). The data then is being converted into the percent of four categories: the construction cost composed of approximately 26 percent materials costs, 45 percent Labor, 22 percent Right of way and 7percent miscellaneous costs. Surveying, engineering, supervision, contingencies, allowances, overhead, and filling fees are the part of miscellaneous cost (Parker, 2004). The details of the projects are shown in Table 3.2. The formulas that have been used to determine the cost of each category are presented as follows:

$$\text{Material} = [(26\% * EC)/\text{Length}]/\text{Diameters}$$

$$\text{Labor} = [(45\% * EC)/\text{Length}]/\text{Diameters}$$

$$\text{R.O.W} = [(22\% * EC)/\text{Length}]/\text{Diameters}$$

$$\text{Misc.} = [(7\% * EC)/\text{Length}]/\text{Diameters}$$

The EC in this formula is a symbol of Estimate of the investment cost and R.O.W is Right Of Way, which is described in part 3.1.2, The Cost of Pipeline.

Table 3.2: Broken Cost of Three under Construction Projects

Name	Type	Length (km)	Diameter (inch)	Estimate Cost	Material 26%	Labor 45%	R.OW 22%	Misc. 7%
TAPI	Onshore	1735	56	$10,000,000,000.00	$26,759.98	$46,315.36	$22,643.06	$7,204.61
IP	Onshore	2775	56	$7,500,000,000.00	$12,548.26	$21,718.15	$10,617.76	$3,378.38
TANAP	Onshore	1841	56	$11,000,000,000.00	$27,741.13	$48,013.50	$23,473.27	$7,468.77
		Av. Onshore pipleline cost (~55% offshre)			$22,349.79	$38,682.33	$18,911.36	$6,017.25
		Av. Offshore pipeline cost			$40,635.99	$70,331.52	$34,384.30	$10,940.46

It should be mentioned that this equation has been provided for computing the cost of onshore pipeline is equal the ~55% of offshore pipeline cost base on this estimation the calculation is followed.

The researches of pipeline construction cost shows that the percentages of R.O.W and Misc. are flexible so it is assumed that the contribution of these two factors in this study is 29% of the total costs.

3.3.2 The Life of the Project

One of the important factors in the big investment is the duration of the exploitation period in each project. As regards of the fluctuations in economic politics, inflation and financial crisis in the world, long-term planning for a project will be risky. In addition, the discovery of a major gas supplier in the Egypt coast will change the oil and gas market situation in the whole of the Mediterranean (Eni, 2015). Therefore, the life of the project with long time duration is not realistic when the gas market faces the predictable condition. So, the life of the project is assumed for 15 years in this study.

3.3.3 The Discount Rate

The fundamental of the financial analysis is understanding the meaning of the following sentences: each estimate of cash flow in the future has a chance of

investment in the bank and received interest rate which has a lower risk. Alternatively, every dollar spent on an investment has its opportunity cost that needs to be taken into consideration. Therefore, in financial analysis in calculations, the discount rate has been used to calculate the present value of future cash flow. As usual the discount rate in investment plan is equal to the higher interest rate that will be paid via bank by adding the few percent to cover the investment risk. The real discount rate was granted as 12%, that is, for a private investor, this rate has been chosen from the midpoint between two relative papers. The first was done by in association with MIT and Cyprus Institute (LNG project) about Cyprus in 2013 with 10% real discount rate (Institute, 2013) and the second case was done via Economides Consulting about Indonesia in 2008. In that case the discount rate was granted as 15% (Porcu, 2008).

3.3.4 The Course of Construction

The course of pipeline construction was assumed to be 3 years in this perusal and also assumed that the construction was completed and the export of natural gas started in 2015.

However, this number is taken from U.S Energy Information Administration site (EIA-C, 2008) and also compared with other projects, which approximately have a same model of pipelines, offshore and onshore, with different distances. For example, the pipeline construction between Turkey and Greece, with 296 km length, takes approximately 2 years to be completed, since July 2005 until September 2007, (Watkins, 2007).

This assumption is same for the pipelines which might be constructed between Cyprus (wellhead) and Turkey (near shore of Cyprus) using about 295 km length

pipes and in Cyprus (Block 12) and Egypt has 400 km length. In addition, if the road of pipeline in Turkey continues to Ankara the construction life will be increased because about 553 km will be added in the construction road.

3.3.5 The Operating Cost

The operating cost has been covered all costs of consumable, staffs and contractors delivering services that will happen when the production will start. The OPC in this perusal has been assumed annually 5% of the capital cost. This ratio was taken from Dr.M.H. Nederlof's personal website, that is an autonomous Dutch counselor in the field of oil and gas (Nederlof, 2010).

3.3.6 The Gas Price at Wellhead

The gas price at the wellhead for Cyprus is not determined yet. Therefore, the U.S wellhead price is used in this study. According to the U.S Energy Information Administration, the gas price at the wellhead is about $3.35 per MMBtu in December, 2012 (EIA-G, 2015). As regards to the measurement in this study that is selected Thousand Cubic Meter or Mcm, the price at wellhead of MMBtu has been converted to Mcm. It should be noted the M symbol that has become before natural gas measurements is equal the 1000 units, so the meaning of MM is one million unit. Considering that 1028 Btu is equal to one cubic foot, the formula that has been utilized to convert the price is as follows:

$ Per MMBtu Multiplied by 1.028 = $ Per Mcf

The price that has been generated from of this formula is $3.4438 per Mcf. In order to determine the price at the wellhead per Mcm the measurement has been changed with consideration that one Cubic meter is equal to ~ 35.31 Cubic feet, so the price at the wellhead per Mcm is equal to $per Mcf multiply to ~35.31, which is shown in

Table 3-3 in detail. As a result, the price is ~$121.616 which is used in subsequent calculations.

Table 3.3: The Gas Price at Wellhead per Mcm

Natural Gas Price at Wellhead /Mcm			
1	C meter	35.3144754	C feet
1028	BTU	1	C feet
1	MMBTU	3.35	Dollar
SO			
1	C feet	0.0034438	Dollar
1000	C meter	121.61599	Dollar
M = 1,000 MM= 1,000,000			

3.3.7 The Import Price of the Natural Gas in Turkey

Turkey is receiving Gas from five countries, respectively the volume of exports consist of Russian 58%, Iran 19%, Azerbaijan 13%, Algeria LG (Liquid Gas) 8% and Nigeria LG 2%, that are presented in Figure 2-12, with different price. The import price of Russian is $418 and Iran is almost $487 per MCM (Thousand Cubic Meter) and the import price from Azerbaijan to Turkey is around $340 per MCM in 2014, which are the base in this perusal all of the data have been obtained by the reporter, which was provided by INSS-an Institute for National Security Studies (Altunsoy, 2014) (Inss, 2014).

3.3.8 The Price of the Natural Gas in Egypt

According to the gas export reports of Egypt and the implication report that has been provided by Dr. Marios Panagiotis Efthymiopoulos, the costly production of natural gas in Egypt has been estimated about $3.5- $5 per MMBtu or ~$127-$181 per Mcm. On the other hand, Egypt Oil and Gas Ministry expects that the cost of new extraction by foreign company will be around $5.54 per MMBtu or ~$201 per Mcf and also the Israel import price is stated at $7 per MMBtu or ~$254 per Mcf to Egypt

(Panagiotis, 2015). The Cyprus news report on the feasibility study about the natural gas export from Cyprus to Egypt has been finished in July 2015 (Cyprus-Mail, 2015). However, the forecast of the gas price in this report is not more than 6$ per MMBtu or $218 per Mcm via pipeline and the LNG Price is around $10 per MMBtu or $363 per Mcm.

Chapter 4

THE ESTIMATION OF NATURAL GAS EXPORT PRICE FROM CYPRUS TO TURKEY

The purpose of this section is to determine the cost and export price of natural gas per 1000 cubic meters or Mcm, which will be exported from Cyprus to Turkey via pipeline unless the export price reaches an unacceptable rate. Therefore, in the last part, based on the result which has been taken from the assumption of this study, it will try to specify the variability of the natural gas transfer to Turkey, whether if it is beneficial for Cyprus or not.

However, in order to achieve this purpose, the calculation is performed in the following segments.

4.1 The Estimation of Export Price to Turkey

As a point of merchant view, the good market is that sells the products with higher price. On the other hand, the buyer looks for the market, which offers the products with a high quality and less price. Therefore, the price of natural gas that will be offered by Cyprus to Turkey should be less than the current price that is imported in the country from other countries. In the following segments, the calculation will be done in Turkey in order to determine the cost of transportation and also at least the export price of Natural gas from Cyprus via pipeline.

4.1.1 The Pipeline Route

The pipeline route from of wellhead to nearest shore in Southern Turkey includes three segments and also second phase, which will be located from the coast till

Ankara. As regards to the reports that are provided to transfer water and natural gas via pipeline between Turkey and Cyprus (Pourbozorgi, 2014) (KKTC, 2012) assumed the shore of Turkey is located in Mersin between Bozyazi and Anamur in Turkey. Figure 4.1 shows the locations.

Figure 4.1: An Overview of Anamur and Bozyazi in Mersin, Turkey (Google Map)

The Pipeline route consists of:

a) ~130 km offshore pipelines that will be laid on the seabed from wellhead to Vasilikos, that is the name of the generating station that has been situated between Larnaka and Limassol in south of Cyprus
b) ~75 km onshore pipeline from Vasilikos to Girne that connects the southern part of the country to the north.
c) ~90 km offshore pipelines that will be laid from Girne to the nearest cost in Mersin, Turkey (Pourbozorgi, 2014).

d) ~553 km onshore pipeline that will be connected the Mersin, Turkey to Ankara. It should be mentioned that Ankara was chosen in order to make the result compared with current the import gas price in Turkey.

Table 4.1: The Pipeline Segments from Wellhead in Cyprus to Ankara

	From	To	Approximately (km)	Pipeline	Depth (m)	Diameter inches
Phase 1	Wellhead	Vasilikos	130	offshore	1700	28
	Vasilikos	Girne	75	Onshore	-	40
	Girne	Mersin, Turkey	90	offshore	1200	24
Phase 2	Mersin, Turkey	Ankara	553	Onshore	-	40

In general, the Gas pipeline between Cyprus and Turkey is composed of around 220km subsea and 627km onshore pipeline.

4.1.2 The Manufacturing Cost - Turkey

According to Part 3.2.1, in order to do the calculation, manufacturing cost and the estimated cost of under construction projects in the Middle East and Asia are chosen. Then the cost of each project was broken into different categories including Material, Labor, R.O.W and miscellanies. This method determines the cost per each category based on the diameter and the length of pipeline.

However, the manufacturing cost for Turkey has been competed in two parts: Wellhead-Mersin, Turkey and Mersin-Ankara.

As regards to the SARI energy groups the onshore construction cost is equal the ~55% of the offshore pipeline cost (SARI/EI, 2008). The formula used to estimate the cost of construction will be as follows:

Onshore pipeline Cost Construction = (M*Dia.*Len.)+ (L*Dia.*Len.)+ (R.O.W*Dia.*Len.)+ (Misc.*Dia.*Len.)

Offshore pipeline Cost Construction = [(M*Dia.*Len.)+ (L*Dia.*Len.)+ (R.O.W*Dia.*Len.)+ (Misc.*Dia.*Len.)]/55%

The symbols that are used in this formula consist of **M**: Material, **Dia**.: Diameter, **Len**: Length, **L**: Labor, **R.O.W**: Right Of Way and **Misc**.: Miscellaneous.

Table 4.2: Pipeline Construction Cost for Turkey

Wellhead to Mersin-Turkey									
From	To	Type	Appr.(km)	Dia.inch	Material	Labor	Misc	R.O.W	C.C
Wellhead	Vassilikos	Offshore	130	28	$147,914,997.11	$256,006,725.76	$39,823,268.45	$125,158,843.71	$568,903,835.03
Vassilikos	Kyrenia	Onshore	75	40	$67,049,380.56	$116,047,004.81	$18,051,756.30	$56,734,091.24	$257,882,232.91
Kyrenia	Mersin	Offshore	90	24	$87,773,734.55	$151,916,079.02	$23,631,390.07	$74,270,083.08	$337,591,286.72
					$302,738,112.21	$523,969,809.60	$81,506,414.83	$256,163,018.03	$1,164,377,354.66
Mersin to Ankara									
From	To	Type	Appr.(km)	Dia.inch	Material	Labor	Misc	R.O.W	C.C
Mersin	Ankara	Onshore	553	40	$494,377,432.64	$855,653,248.80	$133,101,616.48	$418,319,366.08	$1,901,451,664.01
		Total Investment cost from Wellhead to Ankara			$3,065,829,018.67				

The total pipeline manufacturing cost for ~220km offshore and ~628km onshore pipeline from Wellhead-Cyprus to Ankara-Turkey is around $3,065,829,018.67 and for each segment is as follows:

a) The cost of 130km Offshore pipeline between Wellhead to Vasilikos is around $568,903,835.03
b) The cost of 75km Onshore pipeline between Vasilikos to Girne is around $257,882,232.91

c) The cost of 90km Offshore pipeline between Girne to Mersin-Turkey is around $337,591,286.72

d) The cost of 553km Onshore pipeline between Mersin-Turkey to Ankara-Turkey is around $1,901,451,664.01

The total construction cost for 295km pipeline between Wellhead to Mersin-Turkey is around $1,164,377,354.66 and also for 553km from Mersin-Turkey to Ankara-Turkey is around $1,901,451,664.01. It should be mentioned that the offshore construct cost is approximately two times more than an onshore pipeline, which is clear in this part. The result did not change significantly even though the distance was almost doubled.

4.1.3 The Operating Cost- Turkey

In this study, the operating cost is assumed 5% of manufacturing cost which is generally described in Part 3.2.5 in Chapter 3. The operating cost calculation and formula are as follows:

The Annual OPC = Investment Cost * 5%

Table 4.3: The Operating Cost Calculation for Turkey

Wellhead to Mersin-Turkey			Wellhead to Ankara-Turkey	
Investment Cost	$1,164,377,354.66		Investment Cost	$3,065,829,018.67
Operating cost annually percent	5%		Operating cost annually percent	5%
The operating cost per year	$58,218,867.73		The operating cost per year	$153,291,450.93

The annual maintenance and operating cost of 848km offshore and onshore pipeline route based on the assumption in this study is around $153,291,450.93 that consists of Wellhead-Mersin route with $58,218,867.73 and Mersin -Ankara route with $95,072,583.2 annual operating cost.

4.1.4 The Amount of Natural Gas that Will Be Exported to Turkey:

In order to determine the amount of gas that will be exported to Turkey, it is required to specify the domestic consumption in Cyprus, which is completely explained in Chapter 2.

According to U.A Energy Information Administration, the amount of oil imports by South Cyprus was around 60,000 barrels per day at 2012 (EIA, 2012). As regards to the share of population distribution rate in the whole Cyprus, which is 75% in South and 25% in North Cyprus, the oil consumption in this country can be estimated. Therefore, in order to cover the oil consumption in whole Cyprus, it is required to import 80,000 barrels per day. If assumed 25% of total oil demands to be answered by domestic natural gas production, the domestic natural gas consumption is around 3,399.43 thousand cubic meters or Mcm per day (Pourbozorgi, 2014). The same amount is obtained from the last report about import gas tender at 2013, which is announced in Cyprus-mail. The tender is for import annual 0.9 Bcm to the South Cyprus that is equal to annual 1,200 MMcm natural gas consumption for whole Cyprus. Therefore, the domestic consumption of natural gas is about ~3,287.67 Mcm per day which is approximately equal to %25 of total oil that has been exported to whole Cyprus. The formula is as follows:

1 Oil bbl. = ~0.17 Mcm

Convert 25% of Oil Consumption to Gas →20000 bbl. * ~0.17 = 3,399.43 Mcm/ d

The initial capability of natural gas transporting by pipeline is assumed around 11,898.017 thousand cubic meters (Mcm) per day (Pourbozorgi, 2014).

Table 4.4: The PV of Natural Gas That Will Be Exported to Turkey from Cyprus

Title	1000 cubic meters
Export Volume/ Daily	8,498.58
Export Volume/Annual	3,101,981.70
Discount Rate	12%
Life of Project	15 years
PV	21,127,177

The remaining of gas production can be exported to Turkey, which is around 8498.58 thousand cubic meters per day. The Natural Gas that will be exported during the 15 years to Turkey from Cyprus has been calculated and also discounted by discount rate which is assumed 12%. The present value of gas, which will be exported during the life of project to Turkey is around 21,127,177 Mcm.

4.1.5 The Export Price of Natural Gas per Unit – Turkey

The purpose of this section is to determine the cost and selling price per unit, which is equal to thousand cubic meters or Mcm.

In order to achieve the aim of this section the required calculation is done as follows:

a) The investment cost is divided on the present value of the exportable gas to determine the capital cost per unit, which is $55.11 for Wellhead-Mersin and $145.11 per Mcm for Wellhead-Ankara.
b) The operating cost is divided on the annual exportable gas to determine the Operating cost per unit, which is $18.77 for Wellhead-Mersin and $49.42 per Mcm for Wellhead-Ankara.

Table 4.5: The Cost and Export Price of Gas per Mcm for Turkey

Wellhead to Mersin-Turkey					
Titel of Cost	Total Cost	The Amount of Gas That Will Be Issued /1000 cubic meters		Unit Cost /1000 cubic meters	Cost Price /Mcm
		Annual	PV of 15 Years		
Investment Cost	$1,164,377,354.66		21,127,177.01	$55.11	$73.88
Operating Cost / Year	$58,218,867.73	3,101,981.70		$18.77	
	Gas Price at Wellhead			$121.62	
	Export Price to Mersin			$195.50	
Wellhead to Ankara-Turkey					
Titel of Cost	Total Cost	The Amount of Gas That Will Be Issued /1000 cubic meters		Unit Cost /1000 cubic meters	Cost Price /Mcm
		Annual	PV of 15 Years		
Investment Cost	$3,065,829,018.67		21,127,177.01	$145.11	$194.53
Operating Cost /Year	$153,291,450.93	3,101,981.70		$49.42	
	Gas Price at Wellhead			$121.62	
	Export Price to Ankara			$316.15	

The sum of the investment cost and operating cost per unit is equal to the total cost per thousand cubic meters, which is $73.88 for Wellhead-Mersin and $194.53 per Mcm for Wellhead-Ankara. By adding the gas price at wellhead the Export price is achieved, which is $195.50 for Wellhead-Mersin and $316.15 per Mcm for Wellhead-Ankara. The summary of formula that has been used in this part is as follows:

EP = (IC/PV of 15 Years Export) + (AOP/AE) + GPW

It should be mentioned that the symbols, which are used in this formula, consist of the **EP**: Export Price, **IC**: Investment Cost, **AOP**: Annually Operating Cost, **AE**: Annual Export and **GPW**: Gas Price at Wellhead.

4.1.6 The Natural Gas Price in Turkey

In order to determine the export natural gas to Turkey by pipeline from Cyprus is favorable or not, there is a need to specify the import price in Turkey. The cooperation will be impossible unless Cyprus is able to supply NG with less price when compared to other exporter countries to Turkey. The average price of Natural Gas which is paid to Russia, Iran and Azerbaijan is around $421.3 per MCM, this number is obtained from weighted average and it is clear in Table 4.6.

Table 4.6: The Weighted Average of Import Gas Price to Turkey

Name of Countries	Percentage /Total Gas	Price / Mcm	Weighted Average
Russia	58%	$418.00	$242.44
Iran	19%	$487.00	$92.53
Azerbaijan	13%	$340.00	$44.20
Total	90%	$1,245.00	$379.17
Weighted Average of Imported Price			**$421.30**

The formula is as follows:

$$\left[(W_R * P_R) + (W_I * P_I) + (W_A * P_A)\right] / (W_R + W_I + W_A)$$

In this formula **W** is the symbol of weight, which is the Percent share of each country in export gas to Turkey and **P** is an abbreviation of Price. The Weight average import price in Turkey is $421.30 per Mcm.

4.1.7 Conclusion

As regards to the export price that is computed based on the assumption in this study and average import price in Turkey, it can be stated the export natural gas from Cyprus to Turkey is possible.

Table 4.7: The Annual Saving in Turkey

Title	Per Mcm	Annual
Average of Import Price	$421.30	$1,306,864,890.21
Export Price from Cyprus	$316.15	$980,680,042.08
Saving in Turkey	**$105.15**	$326,184,848.13

The export price from Cyprus to Turkey is $316.15 and average import price in Turkey is about $421.30. Therefore, if Turkey imports the NG by pipeline from Cyprus, it will save $105.15 per thousand cubic meters or Mcm and $326,184,848,130.48 annually. Therefore, the cooperation based on assumptions in this study will be favorable.

4.2 The Sensitivity Analysis

In general, the different parameters affect the cost of the project, so the result that taken from investment appraisal will be changed by fluctuation, increasing or decreasing in each parameter. So, the result can be inverted from positive to negative or conversely. In order to prevent the price of imported gas in Turkey, Cost Overruns, Discount rate and operating cost, sensitivity analysis on various parameters consisted of Gas price at the wellhead.

4.2.1 The Sensitivity Analysis of Gas Price at Wellhead

The wellhead price is used to determine the export price per Mcm. In order to specify the project viability this analysis is done by changing price at the wellhead, which is shown in Table 4.8. The scope of investigation is ±30% variation in wellhead price.

Table 4.8: The Sensitivity Analysis of Wellhead Price for Turkey

Percentage Change	Price at Wellhead / MMBtu	Price at Wellhead / Mcm	Export Price /Mcm	Saving in Turkey /Mcm	Saving in Turkey /year
-30.00%	$2.35	$85.13	$279.66	$141.64	$439,360,021.11
-20.00%	$2.68	$97.29	$291.82	$129.48	$401,634,963.45
-10.00%	$3.02	$109.45	$303.98	$117.32	$363,909,905.79
0.00%	$3.35	$121.62	$316.15	$105.15	$326,184,848.13
10.00%	$3.69	$133.78	$328.31	$92.99	$288,459,790.47
20.00%	$4.02	$145.94	$340.47	$80.83	$250,734,732.81
30.00%	$4.36	$158.10	$352.63	$68.67	$213,009,675.15

The wellhead price can be increased till $6.25 per MMBTU or $226.77 per Mcm that is more than +80% change that is breakeven which converts the benefit to zero.

4.2.2 The Sensitivity Analysis of Import Price in Turkey

As regards to the section 4.1.6 the average import price in Turkey is $421.30, which is used to specify the saving in this study. The saving is determined by a different range of percentage change in import price that is presented in Table 4.9. The scope of investigation is around ±30%. All of the parameters remain stable and only the weighted average of import price in Turkey will be changed.

Table 4.9: The Sensitivity Analysis of Import Price in Turkey

Perecentag Change	Average of Import Price in Turkey	Saving in Turkey /Mcm	Saving in Turkey /year
-30.00%	$294.91	-$21.24	-$65,874,618.93
-20.00%	$337.04	$20.89	$64,811,870.09
-10.00%	$379.17	$63.02	$195,498,359.11
0.00%	$421.30	**$105.15**	$326,184,848.13
10.00%	$463.43	$147.28	$456,871,337.15
20.00%	$505.56	$189.41	$587,557,826.17
30.00%	$547.69	$231.54	$718,244,315.19

As regards to the above table the import price has direct relation with saving price in Turkey. The benefit will be growing when the import price goes up and conversely. The recent import price in Turkey is chosen as the midpoint and also the project can save the liability till -24.96%, decreasing value in import price and after this point the project will be unfavorable. The project based on assumption in this study couldn't save its own livability for a long time when faced a negative change in the import price.

4.2.3 The Sensitivity Analysis by the Cost Overrun - Turkey

An unexpected increase of the cost overrun in a project makes the difference between the actual cost and the estimated cost. Although this cost is not the main part of the project cost, it needs to forecast, because this type of cost can put the investor in the bankruptcy situation instead of the profit. However, it considered the various percentages of investment cost in order to estimate the cost overrun or budget overrun that is shown in Table 4.10.

Table 4.10: The Sensitivity Analysis by Cost Overrun - Turkey

Cost Overrun Percentage	Operating Cost	Investment Cost (Inv.C)	Export Price / Mcm	Saving in Turkey /Mcm	Saving in Turkey /year
0.00%	**$153,291,450.93**	**$3,065,829,018.67**	**$316.15**	**$105.15**	**$326,184,848.13**
5.00%	$160,956,023.48	$3,219,120,469.60	$325.87	$95.43	$296,013,374.86
10.00%	$168,620,596.03	$3,372,411,920.54	$335.60	$85.70	$265,841,901.58
15.00%	$176,285,168.57	$3,525,703,371.47	$345.33	$75.97	$235,670,428.31
20.00%	$183,949,741.12	$3,678,994,822.40	$355.05	$66.25	$205,498,955.03
30.00%	$199,278,886.21	$3,985,577,724.27	$374.51	$46.79	$145,156,008.48
40.00%	$214,608,031.31	$4,292,160,626.14	$393.96	$27.34	$84,813,061.94
50.00%	$229,937,176.40	$4,598,743,528.01	$413.41	$7.89	$24,470,115.39

In this analysis, the investment cost, operating cost, export price and also saving price in Turkey are influenced by cost overrun. In general, by increasing the cost of the project the cost per unit will be increased, incremental in the cost lead to a decrease in benefit and the loss of the investor motivation in continuing the project or bankruptcy.

The scope of investigation is around 5% up to 50 % of investment cost as budget overrun. As it is shown in this table, the project based on assumption in this study can save the livability till ~54% change in the cost, but at this point the saving price for Turkey is not significant and in right this is equal to zero, so it can be said that this is a break even.

4.2.4 The Sensitivity Analysis of Discount Rate - Turkey

The Discount Rate (DR) is an independent variable, but it affected the output of this project. The investment cost per unit or Mcm calculated are based on the Present Value (PV) of amount export gas that will be supplied to Turkey. Therefore, that

will be changed by varying the DR. The saving price in Turkey is the dependent variable.

The sensitivity analysis is done for different rate in order to determine the saving price behavior in the face of discount rate changes. The scope of investigation is from 8% to 15%. The data presented in Table 4.11 is cleared. In addition, all the variables remain stable.

Table 4.11: The Sensitivity Analysis of Discount Rate - Turkey

Discount Rate	PV of Exports Gas During 15 years	Investment Cost	Investment Cost / Mcm	Total Cost /Mcm	Saving in Turkey /Mcm	Saving in Turkey /year
8%	26,551,346.25	$3,065,829,018.67	$115.47	$286.50	$134.80	$418,143,453.58
12%	**21,127,177.01**	**$3,065,829,018.67**	**$145.11**	**$316.15**	**$105.15**	**$326,184,848.13**
15%	18,138,435.04	$3,065,829,018.67	$169.02	$340.06	$81.24	$252,013,819.99

The highlights line in the table shows the output that is taken from the assumption in this study. The fluctuation on DR is affected on the Investment Cost per Mcm and also the saving price in Turkey. Therefore, by increasing the Discount rate, the cost per MCM will go up and the saving price will be decreased.

The saving price by 8% discount rate is $134.80 and by 15% is $81.24 per Mcm. In this project the 24.36% break-even that makes the savings is equal to zero.

4.2.5 The Sensitivity Analysis of the Operating Cost – Turkey

The operating cost is assumed 5% of the investment cost. If the percentage of the operating cost changes, the cost per Mcm will be changed, by considering the nature of the expenses that has a direct effect on saving price. The scope investigation is 3%

as minimum point till 9% of the investment cost; the data of this sensitivity analysis is shown in Table 4.12.

Table 4.12: The Sensitivity Analysis of Operating Cost – Turkey

Percentage of Operating Cost	Operating Cost / Mcm	Total Cost /Mcm	Saving in Turkey /Mcm	Saving in Turkey /year
3%	$11.26	$296.38	$124.92	$387,501,428.50
4%	$15.01	$306.26	$115.04	$356,843,138.32
5%	**$18.77**	**$316.15**	**$105.15**	**$326,184,848.13**
6%	$22.52	$326.03	$95.27	$295,526,557.94
7%	$26.28	$335.91	$85.39	$264,868,267.76
8%	$30.03	$345.80	$75.50	$234,209,977.57
9%	$33.78	$355.68	$65.62	$203,551,687.38

According to the above Table, the project can save the stability unless the percentage of Operating Cost goes up more than 3 times. The savings will go down if the operating cost per Unit increases. The scope of investigation starts at 3% that is chosen as a minimum point by the largest amount of saving price that is about $124.92 and 16% break-even point that makes the savings equal to zero.

4.2.6 The Sensitivity Analysis of the Amount of Export - Turkey

The cost per unit estimates based on volume of export so its fluctuation can make a significant effect on the result, by the soaring amount of Export the price per unit will be decreased and conversely. The investment cost is the fixed cost so for total production is fixed and variable per unit.

The actual capabilities of natural gas production in Cyprus did not determined yet. So it is likely that the amount of exportable gas doesn't remain stable. Considering the importance of this issue the sensitivity analysis is done for this factor. In order to

find the relation between savings price and Export quantity, their Behavior and reactions will be checked by ± 50% change in Export volume.

Table 4.13: The Sensitivity Analysis of Amount Export - Turkey

Percentage Change	Total Export / Day	Total Export Annual /Mcm	PVof Export Gas During 15 years	Investment Cost	Investment Cost / Mcm	Operating Cost / Mcm	Total Cost /Mcm	Saving in Turkey /Mcm	Saving in Turkey /year
-50.00%	4,249.29	1,550,990.85	10,563,588.50	3,065,829,018.67	$290.23	$98.83	$510.68	-$89.38	-$138,622,308.68
-40.00%	5,099.15	1,861,189.02	12,676,306.20	3,065,829,018.67	$241.86	$82.36	$445.83	-$24.53	-$45,660,877.32
-30.00%	5,949.01	2,171,387.19	14,789,023.91	3,065,829,018.67	$207.30	$70.60	$399.52	$21.78	$47,300,554.05
-20.00%	6,798.86	2,481,585.36	16,901,741.61	3,065,829,018.67	$181.39	$61.77	$364.78	$56.52	$140,261,985.41
-10.00%	7,648.72	2,791,783.53	19,014,459.31	3,065,829,018.67	$161.24	$54.91	$337.76	$83.54	$233,223,416.77
0.00%	8,498.58	3,101,981.70	21,127,177.01	3,065,829,018.67	$145.11	$49.42	$316.15	$105.15	$326,184,848.13
10.00%	9,348.44	3,412,179.87	23,239,894.71	3,065,829,018.67	$131.92	$44.92	$298.46	$122.84	$419,146,279.49
20.00%	10,198.30	3,722,378.04	25,352,612.41	3,065,829,018.67	$120.93	$41.18	$283.72	$137.58	$512,107,710.85
30.00%	11,048.15	4,032,576.21	27,465,330.11	3,065,829,018.67	$111.63	$38.01	$271.25	$150.05	$605,069,142.22
40.00%	11,898.01	4,342,774.38	29,578,047.81	3,065,829,018.67	$103.65	$35.30	$260.57	$160.73	$698,030,573.58
50.00%	12,747.87	4,652,972.55	31,690,765.51	3,065,829,018.67	$96.74	$32.94	$251.30	$170.00	$790,992,004.94

As regards to the Table 4.13 the export volume is a variable parameter that is affected on export price or in the other world that is a main factor to determine the cost of production. The break-even or minimum point with zero profitability accrued by -35% change in amount of export that is ~ 5516.58 MCM per day.

4.2.7 Two Way Sensitivity Analysis – Turkey

In this part the sensitivity analysis is performed on two variable together. Variables were selected according to their influence on the outcome of the project. The sensitivity analysis of Export quantity and average import price in Turkey is done as follows:

Table 4.14: The Sensitivity Analysis for Export Quantity and Import Price-Turkey

		Amount of Export /Mcm per Day									
	$105.15	4,249.29	5,099.15	5,949.01	6,798.86	7,648.72	8,498.58	9,348.44	10,198.30	11,048.15	11,898.01	12,747.87
Average Import Price in Turkey	$294.91	-215.766613	-150.9230486	-104.6062481	-69.86902246	-42.85083714	-21.2363	-3.55169	11.18548052	23.65525451	34.343764	43.60713547
	$337.04	-173.636613	-108.7930486	-62.47624812	-27.73902246	-0.72083714	20.893698	38.57831	53.31548052	65.78525451	76.473764	85.73713547
	$379.17	-131.506613	-66.66304858	-20.34624812	14.39097754	41.40916286	63.023698	80.70831	95.44548052	107.9152545	118.603764	127.8671355
	$421.30	-89.3766128	-24.53304858	21.78375188	56.52097754	83.53916286	105.1537	122.83831	137.5754805	150.0452545	160.733764	169.9971355
	$463.34	-47.3366128	17.50695142	63.82375188	98.56097754	125.5791629	147.1937	164.87831	179.6154805	192.0852545	202.773764	212.0371355
	$505.56	-5.11661281	59.72695142	106.0437519	140.7809775	167.7991629	189.4137	207.09831	221.8354805	234.3052545	244.993764	254.2571355
	$547.69	37.01338719	101.8569514	148.1737519	182.9109775	209.9291629	231.5437	249.22831	263.9654805	276.4352545	287.123764	296.3871355

In the above table, the first row is presented the different numbers for exportable gas from Cyprus to Turkey. The Numbers have been selected by taking a ±50% change in the volume of exports. The first column shows the ±30% fluctuation in average import price in Turkey. In this table behavior of saving price investigation when it is faced with the change of variables together.

Considering that, the increase or decrease in the amount of both variables has the same impact on the results so for saving the project in the positive mode require that each of the variables move in opposite directions to neutralize the negative effects by each other.

It should mention that the increasing volume of export is depended on pipeline capable. Therefore, in some situation increment in export volume led to cost for development the project as a result the saving price will be decreased. In this situation need to further investigate.

Table 4.15: The Sensitivity Analysis of Cost Overrun and Operating Cost-Turkey

		Cost Overrun Percentage							
	$105.15	0%	5%	10%	15%	20%	30%	40%	50%
Operating Cost Percentage	3%	124.9206043	116.182434	107.4442638	98.70609351	89.96792324	72.491583	55.015242	37.53890165
	4%	115.0371514	105.8048084	96.57246553	87.34012261	78.1077797	59.643094	41.178408	22.71372222
	5%	105.1536984	95.42718284	85.70066728	75.97415172	66.24763616	46.794605	27.341574	7.888542794
	6%	95.27024545	85.04955724	74.82886903	64.60818083	54.38749262	33.946116	13.50474	-6.936636632
	7%	85.3867925	74.67193164	63.95707079	53.24220993	42.52734908	21.097627	-0.3320943	-21.76181606
	8%	75.50333955	64.29430605	53.08527254	41.87623904	30.66720554	8.2491385	-14.168928	-36.58699549
	9%	65.6198866	53.91668045	42.2134743	30.51026815	18.80706199	-4.59935	-28.005763	-51.41217491

The cost overrun and operating cost are variables, which are chosen for second sensitivity analysis in this section. The first row shows the percentage of Cost overrun and column demonstrates the percentage of Operation cost. As regards to the nature of the cost overrun, an increase in this variable lead to increment the investment cost, as a result all of the variable, which is related with per unit cost, will be increased.

According to the Table 4.15 if the percentage of operating cost stay at 5% and cost overrun at 50%, despite the saving price being very small but the result remains positive. As well as if Operating cost percentage is increased to 9%, the cost overrun cannot be more than 20%, otherwise the result of the project, saving price, will be negative.

Chapter 5

THE ESTIMATION OF NATURAL GAS EXPORT PRICE FROM CYPRUS TO EGYPT

This chapter is going to determine the Export price per MCM or thousand cubic meters of natural gas from Cyprus to Egypt and also the computation will be continued with sensible analysis of independent and dependent variables, for instance, the percentage of operating costs, discount rate and cost overrun.

5.1 The Estimation of Export Price to Egypt

Egypt is located around the Levant basin near the block 12. According to the Egypt daily news that is published in June 2015 the agreement signed between the Cyprus and Egypt in order to check on natural gas export to Egypt via 400 km pipelines (dailynewsegypt, 2015). The treatment station in Egypt and Aphrodite field in Cyprus will be linked through Mediterranean Sea that is around 180 km.

Table 5.1: Data for Export Gas from Cyprus to Egypt

From	To	Length (km)	Pipeline	Diameter inches	1000 Cubic Meter /day
Wellhead (Block 12)	Egypt	180	Offshore	28	8,498.58

Given that, the pipeline technique information is not yet available. The pipeline diameter is assumed 28 inches in this study. It should be mentioned that the exportable gas to Egypt from Cyprus is 8,498.58 Mcm per day.

5.1.1 The Manufacturing Cost-Egypt

According to Part 3.2.1 which described this Method in detail, the cost of the project is classified in four groups consisting of Material, Labor, Right of Way and Miscellaneous.

However, based on this method, the total construction cost of onshore pipeline per diameter and the length of the route is $85,960.74 and for offshore pipeline is around $156,292.26 per inch and km.

The calculation of manufacturing cost based on this estimation is presented in the Table below.

Table 5.2: Calculation of the Pipeline Construction Cost

Wellhead to Egypt									
From	To	Type	Appr.(km)	Dia.inches	Material	Labor	Misc	R.O.W	C.C
Wellhead (Block 12)	Egypt	Offshore	180	28	$204,805,380.61	$354,470,851.06	$55,139,910.16	$173,296,860.52	$787,713,002.35

The construction cost of offshore pipeline with 28 inch diameter, between Cyprus and Egypt based on assumptions in this study consists of $204,805,380.61 Material, $354,470,851.06 Labor and $228,436,770.68 Miscellaneous and Right of Way. The total cost is equal to $787,713,002.35 for ~ 180 km length undersea pipeline (dailynewsegypt, 2015).

5.1.2 The Operating Cost - Egypt

According to the section 3.2.5 the percent of annual operating cost is 5% which is percentage of manufacturing cost that is shown in Table 5.3.

Table 5.3: The Annual Operating Cost for Egypt

Wellhead to Egypt	
Investment Cost	$787,713,002.35
Percent of Annual Operating Costs	5%
Operating Cost for One Year	$39,385,650.12

The annual maintenance and operating cost of 180km offshore pipeline route based on the assumption in this study is around $39,385,650.12 from wellhead- Cyprus to treatment station in Egypt.

5.1.3 The Amount of Natural Gas that Will Be Exported to Egypt

In order to complete this computation, it is required to determine the amount of natural gas per cubic meters that will be exported annual (365 days).The amount of gas is around 8498.58 thousand cubic meters per day. As regards to the daily export, the amount of annual export of natural gas is 3,101,983 Mcm.

The Natural Gas that will be exported during the 15 years to Egypt from Cyprus is calculated and also discounted by the discount rate which is assumed 12%. The present value of gas, which will be exported during the life of project to Egypt, is around 21,127,177Mcm.

5.1.4 The Export Price of Natural Gas per Unit – Egypt

In order to determine the cost per 1000 cubic meters, the manufacturing cost is divided on the PV of amount exportable gas and operating cost is divided on annual exportable natural gas and finally the sum of these two factors determine the cost of each unit. As well as by adding the gas price at the wellhead on per unit cost, the export price to Egypt will be specified. The formula is shown in section 4.1.5.

Table 5.4: The Cost and Export Price of Gas per Mcm for Egypt

Wellhead to Egypt					
Titel of Cost	Total Cost	The Amount of Gas That Will Be Issued /1000 cubic meters		Unit Cost /1000 cubic meters	Cost Price /Mcm
		Annual	PV of 15 Years		
Investment Cost	$787,713,002.35		21,127,185.88	$37.28	$49.98
Operating Cost / Year	$39,385,650.12	3,101,983.00		$12.70	
	Gas Price at Wellhead			$121.62	
	Export Price to Egypt			$171.60	

The cost price per Mcm is around $49.98 and the export gas price based on this formula is $171.60 per Mcm that is shown in Table 5.4.

5.1.5 The Natural Gas Price in Egypt

In order to determine that the export of natural gas to Egypt by pipeline from Cyprus is favorable or not, it is required to specify the import, extraction and production price in Egypt (Section 3.2.8). The cooperation will be impossible in providing that Cyprus is able to supply the NG with certainly price. The cost of domestic production of natural gas in Egypt has been estimated about $3.5- $5 per MMBtu or ~$127-$181, the average of domestic production is ~$154, and also the forecasted cost of new extraction by foreign company will be around $5.54 per MMBtu or ~$201 per Mcm as well as Israel LNG import price is stated at $7 per MMBtu that is equal to ~$255.47 per Mcm of Natural gas (Panagiotis, 2015).

5.1.6 Conclusion

The Export gas price from Wellhead in Cyprus to treatment station in Egypt based on this study's assumption is about $171.60 that has been compared with other price in Egypt is as follows:

Domestic Production ~$154 > $171.60 Export price by Cyprus

Foreign Production ~ $201 < $171.60 Export price by Cyprus

Import price of Israel ~$255 < $171.60 Export price by Cyprus

In addition, in July 2015, the Cyprus news reported the feasibility study about the natural gas export from Cyprus to Egypt is finished. This report is provided by engineering company Enppi and also the results are under the review by Egypt state company, EGAS (Cyprus-Mail, 2015). However, the forecast of the gas price in this report is not more than 6$ per MMBtu or $218 per Mcm via pipeline and the LNG price is around $10 per MMBtu or $362.3 per Mcm.

Table 5.5: The Annual Saving in Egypt

Title	Per Mcm	Annual
Liquid Natural Gas Price	$255.47	$2,171,133.14
Cyprus Export Price	$171.60	$1,458,333.56
Saving in Egypt	**$83.87**	$712,799.59

The price of LNG exportable from Israel is chosen in order to determine the saving for Egypt. The Israel LNG price is $255.47 and $171.60 is the export natural gas price from the Cyprus, the saving will be around $83.87 per Mcm and $712,799.56 per year. Therefore, the cooperation based on the assumptions in this study will be favorable. The following sensitivity analysis has been done by various parameters.

5.2 The Sensitivity Analysis

In general, determining the viability of the project faced by fluctuation in different dependent variables is one of the important parts in each study. In order to avoid unexpected changes that lead to changes in the outcome of the investigation, the sensitivity analysis has been done in different parameters such as Discount rate, Cost overrun and Gas price at the wellhead.

5.2.1 The Sensitivity Analysis of the Gas Price at Wellhead

In this part, the sensitivity analysis of the gas price at the wellhead has been performed. The reaction of saving in the face of changes in the wellhead price is presented in Table 5.6. The scope of investigation is ±30% variation of gas price at wellhead.

Table 5.6: The Sensitivity Analysis of Wellhead Price for Egypt

Percentage Change	Price at Wellhead / MMBtu	Price at Wellhead / Mcm	Export Price /Mcm	Saving in Egypt /Mcm	Saving in Egypt /year
-30.00%	$2.35	$85.31	$135.29	$120.18	$1,021,326.05
-20.00%	$2.68	$97.29	$147.27	$108.20	$919,512.32
-10.00%	$3.02	$109.64	$159.62	$95.85	$814,613.32
0.00%	$3.35	$121.62	$171.60	$83.87	$712,799.59
10.00%	$3.69	$133.96	$183.94	$71.53	$607,900.59
20.00%	$4.02	$145.94	$195.92	$59.55	$506,086.86
30.00%	$4.36	$158.28	$208.26	$47.21	$401,187.86

As it can be seen in the above Table, the change in wellhead price will be effected by the export price. However, the change direction between export price and gas price at the wellhead is the same that because the gas price at the wellhead is the kind of cost, so as regards, the nature of costs increases the amount of this item leading to the incremental total cost and decreasing the benefit.

The project based on the assumption in this study could save the livability for a long time. The wellhead gas price doesn't have a significant effect on the saving price. The breakeven in this analysis is 70% increase in wellhead price that makes the gas price at wellhead equal to ~ 5.7/ MMBtu and ~ $206/ Mcm.

5.2.2 The Sensitivity Analysis of the Liquid Natural Gas Price in Egypt

According to the section 2.4, Egypt is one of the countries that have been converted from an exporter of natural gas to importer because of the significant reduction gas reserves in this country. As a result, Egypt tries to find the best solution to solve the lack of energy for short and or long time, in fact, until the access to new resources in this country by new survey via foreign countries. Therefore, the specific price of import gas in Egypt is not available. In this study, the price of two accessible ways in order to carry over the natural gas has been compared to each other which consist of the natural gas price by a pipeline that is obtained from this study and LNG export price to Egypt by Israel.

Table 5.7: The Sensitivity Analysis of Liquid Natural Gas Price in Egypt

Perecentag Change	Liquid Natural gas price for Egypt/ Mcm	Saving in Egypt /Mcm	Saving in Egypt /year
-30.00%	$178.83	$7.23	$61,459.65
-20.00%	$204.38	$32.78	$278,572.96
-10.00%	$229.92	$58.33	$495,686.27
0.00%	**$255.47**	**$83.87**	$712,799.59
10.00%	$281.02	$109.42	$929,912.90
20.00%	$306.56	$134.97	$1,147,026.22
30.00%	$332.11	$160.51	$1,364,139.53

As regards to the above table the saving price in Egypt is changed by the fluctuation in the liquid natural gas price with ± 30% change.

The breakeven is happening with around -32% change in the LNG price that is around $171.06 per Mcm. At this point, the profit that is a result of this trade is equal to zero or unprofitable point.

5.2.3 The Sensitivity Analysis by Cost Overrun - Egypt

According to Part 4.2.3, the cost overrun unexpectedly increased the cost of the project. The scope of investigation is around 5% up to 30 % of investment cost as budget overrun.

Table 5.8: The Sensitivity Analysis by Cost Overrun – Egypt

Cost Overrun Percentage	Operating Cost	Investment Cost (Inv.C)	Total Cost /MCM	Export Price / MCM	Saving in Egypt /Mcm	Saving in Egypt /year
0.00%	**$39,385,650.12**	**$787,713,002.35**	**$49.98**	**$171.60**	**$83.87**	**$712,799.59**
5.00%	$41,354,932.62	$827,098,652.47	$52.48	$174.10	$81.37	$691,561.09
10.00%	$43,324,215.13	$866,484,302.59	$54.98	$176.60	$78.87	$670,322.60
15.00%	$45,293,497.64	$905,869,952.70	$57.48	$179.09	$76.38	$649,084.10
20.00%	$47,262,780.14	$945,255,602.82	$59.98	$181.59	$73.88	$627,845.61
30.00%	$51,201,345.15	$1,024,026,903.06	$64.98	$186.59	$68.88	$585,368.62

The cost overrun percentage is affecting the investment cost by +30% change in total cost. The Break-even in this project is +68%, that means the projects can handle 68% with an increase at an investment cost by an unexpected cost.

5.2.4 The Sensitivity Analysis of Discount Rate -Egypt

The discount rate in this study has been used to discount the amount of natural gas that will be exported to Egypt from Cyprus. The flexibility of discount rate affects the export gas price and also the investment cost per unit. The table data which has been utilized for sensitivity analysis of discount rate is presented in the table below.

Table 5.9: The Sensitivity Analysis of Discount Rate- Egypt

Discount Rate	PV of Exports Gas During 15 years	Investment Cost	Investment Cost / Mcm	Total Cost /Mcm	Saving in Egypt /Mcm	Saving in Egypt /year
8%	26,551,357.40	$29.67	$42.36	$163.98	$91.49	$777,531.67
12%	**21,127,185.88**	**$37.28**	**$49.98**	**$171.60**	**$83.87**	$712,799.59
15%	18,138,442.66	$43.43	$56.12	$177.74	$77.73	$660,588.65

Some of the parameters that have been presented in Table 5-9 are changed by the fluctuation in the discount rate, for instance, investment cost / unit and export price /Mcm. The Break-even in this project is 48% that means the discount rate increases from 12% to 48% which is not a logical for discount rate. Therefore, the discount rate base on this analysis does not have a significant effect on the saving in Egypt.

5.2.5 The Sensitivity Analysis of the Operating Cost -Egypt

As regards to Part 4.2.5, the scope of analysis is started form 3% to 9% and surveys the saving behavior in the face of change in operating cost.

Table 5.10: The Sensitivity Analysis of Operating Cost – Egypt

Percentage of Operating Cost	Operating Cost / Mcm	Total Cost /Mcm	Saving in Egypt /Mcm	Saving in Egypt /year
3%	$7.62	$166.52	$88.95	$755,961.95
4%	$10.16	$169.06	$86.41	$734,380.77
5%	**$12.70**	**$171.60**	**$83.87**	**$712,799.59**
6%	$15.24	$174.14	$81.33	$691,218.41
7%	$17.78	$176.68	$78.79	$669,637.23
8%	$20.32	$179.22	$76.25	$648,056.05
9%	$22.85	$181.75	$73.72	$626,474.88

The highlight line in the above table illustrates the data that has been used in this study.

The saving price is increased by decreasing the percentage of operating costs, in addition to increment this varies the annual operating cost and total cost per unit will increase and reduce the saving in Egypt. The Break-even in this project is ~38% that means the percentage of operating costs increases from 5% to 38%.

5.2.6 The Sensitivity Analysis of the Amount of Export - Egypt

The value of Export is the one of the important factors to determine the export natural gas price per unit. Therefore, any changes on this parameter has a remarkable effect on the result that has been taken from of the data assumed in this perusal. However, each unexpected economic and political decision can change this quantity. Considering the importance of this issue, the sensitivity analysis has been done for this factor.

Table 5.11: The Sensitivity Analysis of Amount Export -Egypt

Percentage Change	Total Export / Day	Total Export Annual /Mcm	PVof Export Gas During 15 years	Investment Cost	Investment Cost / Mcm	Operating Cost / Mcm	Total Cost /Mcm	Export Price /Mcm	Saving in Egypt /Mcm	Saving in Egypt /Year
-50.00%	4,249.29	1,550,991.50	10,563,592.94	787,713,002.35	74.57	25.39	99.96	221.58	33.89	144,014.85
-40.00%	5,099.15	1,861,189.80	12,676,311.53	787,713,002.35	62.14	21.16	83.30	204.92	50.55	257,771.79
-30.00%	5,949.01	2,171,388.10	14,789,030.12	787,713,002.35	53.26	18.14	71.40	193.02	62.45	371,528.74
-20.00%	6,798.87	2,481,586.40	16,901,748.70	787,713,002.35	46.61	15.87	62.48	184.09	71.38	485,285.69
-10.00%	7,648.73	2,791,784.70	19,014,467.29	787,713,002.35	41.43	14.11	55.53	177.15	78.32	599,042.64
0.00%	8,498.58	3,101,983.00	21,127,185.88	787,713,002.35	37.28	12.70	49.98	171.60	83.87	712,799.59
10.00%	9,348.44	3,412,181.30	23,239,904.47	787,713,002.35	33.89	11.54	45.44	167.05	88.42	826,556.54
20.00%	10,198.30	3,722,379.60	25,352,623.06	787,713,002.35	31.07	10.58	41.65	163.27	92.20	940,313.49
30.00%	11,048.16	4,032,577.90	27,465,341.65	787,713,002.35	28.68	9.77	38.45	160.06	95.41	1,054,070.43
40.00%	11,898.02	4,342,776.20	29,578,060.23	787,713,002.35	26.63	9.07	35.70	157.32	98.15	1,167,827.38
50.00%	12,747.88	4,652,974.50	31,690,778.82	787,713,002.35	24.86	8.46	33.32	154.94	100.53	1,281,584.33

In order to find the relation between savings and export quantity, saving reactions will be checked by ± 50% change in export volume. As regards to the Table 5-11 almost, all factors that have been affected on unit price will be changed by the fluctuation in export volume.

As it is illustrated by the table, the project based on assumption in this study can save the livability till approximately -63% change in the export volume that is equal to

3173 Mcm, but at this point the saving price is not significant and in fact this is equal to zero and also exceeds 63% decrease will invert the outcome and led to cancel the project.

5.2.7 Two Way Sensitivity Analysis - Egypt

As regards to Part 4.2.7, the sensitivity analysis is done on two variables together. Variables were selected according to their influence on the outcome of the project. The sensitivity analysis of the export quantity and average import price in Egypt is performed as follows:

Table 5.12: The Sensitivity Analysis for Export Quantity and Import Price - Egypt

		Amount of Export /Mcm per day									
	$83.87	4,249.29	5,099.15	5,949.01	6,798.86	7,648.72	8,498.58	9,348.44	10,198.30	11,048.15	11,898.01	12,747.87
LNG Import price in Egypt	$178.83	-42.7485483	-26.08808935	-14.18776949	-5.262625868	1.679240671	7.2327306	11.77649299	15.56296013	18.76685802	21.51309006	23.893157
	$204.38	-17.1985483	-0.538089348	11.36223051	20.28737413	27.22924067	32.782731	37.32649299	41.11296013	44.31685802	47.06309006	49.443157
	$229.92	8.341451652	25.00191065	36.90223051	45.82737413	52.76924067	58.322731	62.86649299	66.65296013	69.85685802	72.60309006	74.983157
	$255.47	33.89145165	50.55191065	62.45223051	71.37737413	78.31924067	83.872731	88.41649299	92.20296013	95.40685802	98.15309006	100.533157
	$281.02	59.44145165	76.10191065	88.00223051	96.92737413	103.8692407	109.42273	113.966493	117.7529601	120.956858	123.7030901	126.083157
	$306.56	84.98145165	101.6419107	113.5422305	122.4673741	129.4092407	134.96273	139.506493	143.2929601	146.496858	149.2430901	151.623157
	$332.11	110.5314517	127.1919107	139.0922305	148.0173741	154.9592407	160.51273	165.056493	168.8429601	172.046858	174.7930901	177.173157

In the above table, the first row presents the different numbers for exportable gas from Cyprus to Egypt. The Numbers have been selected by taking a ±50% change in the volume of exports. The first column shows the ±30% fluctuation in LNG import price in Egypt. In this table, the behavior of saving price investigation faces the change of variables together.

As regards to Table 5.12, the project loses liability when confronted with 30% decrease in LNG import price and 20% decrement in Export gas quantity at the same time.

According to trend changes, the variables, LNG price and Export Quantity, there is a need to move in the opposite direction to save the project viability.

Table 5.13: The Sensitivity Analysis of Cost Overrun and Operating Cost –Egypt

		Cost Overrun Percentage							
	$83.87	0%	5%	10%	15%	20%	30%	40%	50%
Operating Cost Percentage	3%	88.95152222	86.70639785	84.46127348	82.21614911	79.97102474	75.480776	70.99052726	66.50027852
	4%	86.41213692	84.04004329	81.66794965	79.29585602	76.92376238	72.179575	67.43538784	62.69120057
	5%	83.87275163	81.37368873	78.87462583	76.37556293	73.87650003	68.878374	63.88024843	58.88212263
	6%	81.33336633	78.70733417	76.081302	73.45526984	70.82923767	65.577173	60.32510902	55.07304469
	7%	78.79398104	76.04097961	73.28797818	70.53497675	67.78197532	62.275972	56.7699696	51.26396675
	8%	76.25459574	73.37462505	70.49465435	67.61468366	64.73471297	58.974772	53.21483019	47.4548888
	9%	73.71521045	70.70827049	67.70133053	64.69439057	61.68745061	55.673571	49.65969078	43.64581086

Table 5.13, as second two way sensitivity analysis, investigates the +50% change in capital cost by adding the cost overrun and also operating the cost by changing the percentage from 3% to 9%.

However, with the concurrent increase in this variable profits of the project, it is reduced but this scope of changes could not invert the project result.

Table 5.14: The Sensitivity Analysis for Gas Price at the Wellhead and LNG Import Price-Egypt

		Natural Gas Price at Wellhead/Mcm						
	$83.87	85.31	97.29	109.62	121.62	133.96	145.94	158.28
LNG Import Price in Egypt	$178.83	43.53874201	31.55874201	19.22874201	7.228742009	-5.111257991	-17.09126	-29.431258
	$204.38	69.08874201	57.10874201	44.77874201	32.77874201	20.43874201	8.458742	-3.88125799
	$229.92	94.62874201	82.64874201	70.31874201	58.31874201	45.97874201	33.998742	21.65874201
	$255.47	120.178742	108.198742	95.86874201	83.86874201	71.52874201	59.548742	47.20874201
	$281.02	145.728742	133.748742	121.418742	109.418742	97.07874201	85.098742	72.75874201
	$306.56	171.268742	159.288742	146.958742	134.958742	122.618742	110.63874	98.29874201
	$332.11	196.818742	184.838742	172.508742	160.508742	148.168742	136.18874	123.848742

The natural gas price at the wellhead and LNG import price in Egypt are tow variables, which are chosen for third Table of two-way sensitivity analysis. The scope of analysis is ±30% variation in amount of variables. The import and export gas price will be decreased when the gas price at the wellhead is decreased. In Table 5-14, the change in price trend at the wellhead as well as its impact on factors are completely displayed**.**

Chapter 6

CONCLUSION

The purpose of this study is to determine the suitable market with adequate motivation in order to import natural gas from new reserves in Cyprus by pipeline. In order to achieve this purpose the feasibility study is performed on the two reasonable gas markets, Turkey and Egypt.

The results based on existing data and assumptions in this study show the Export Natural gas from Cyprus to Turkey and Egypt is favorable. It should be mentioned that the length of pipeline route and pipeline diameter or the general pipeline technical specification have a significant effect on the result.

The calculations continue with a sensibility analysis of various variables. The result presented in the project is at high risk especially by reducing the export gas quantity and reducing the gas import price in the target countries at the same time.

Finally, Turkey is the best option for natural gas export from Cyprus since the import price in Turkey is more than the import price in Egypt. Also, the gas market in Egypt is a temporary for Cyprus as Egypt has recently discovered a significant amount of natural gas reserve. In addition to these, the total annual savings of Turkey by exporting gas from Cyprus is more than the savings of Egypt.

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APPENDIX

Nathan Parker, the member of Institute of Transportation Studies in California at 2003, provided a report and provided a way to estimate the gas pipeline construction cost (Parker, 2004). In this report Nathan collected the construction cost to produce a passable equation to estimate the cost of pipeline projects that used the construction cost of the 893 projects in the US during the 13 years. Then the cost of the projects is divided into four categories including Material cost, Labor cost, Miscellanies cost and Right of Way cost. These parameters are used in Regression analysis, which is a statistical process for estimating the relationships among variables, in order to reach linear equation based on Pipeline Diameter and Length. The following Table shows the linear equation used in this project obtained from the statistical program which is the output of Nathan Parker study.

Materials Cost (dia, length) = [330.5(dia)^2 + 687(dia) + 26,960](length) + 35,000
Labor Cost (dia, length) = [343(dia)^2 + 2,074(dia) +170,013](length) + 185,000
Misc. Cost (dia, length) = [8,417(dia) + 7,324](length) + 95,000
Right of Way Cost (dia, length) = [577(dia)^2 + 29,788](length) + 40,000
(dia) is in inches, (length) is in miles, and Cost is in dollars

It should be mentioned that the length in this formula is based on inch so the length will be converted from km to inch and also one kilometer is equal the ~ 0.6 miles. It should be mentioned that the formula is taken from data at 1991-2003, so, the result must be updated. In order to calculate the cost of the project in 2013, the global inflation rates of 2004 -2013 (IndexMundi-a, 2013) were collected and the average

for updating the output of the formula was taken. The global inflation rates during the 10 years and 4.40% are the average will be used in the calculation.

NO.	1	2	3	4	5	6	7	8	9	10
Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Inflation	3.60%	4.10%	4.40%	5.10%	9%	2.90%	3.60%	5%	3.70%	2.60%
Avrage	4.40%									

Appendix A: Turkey

Wellhead to Turkey

From	To	Appr.(km)	Appr.(mill)	Dia.inches	Material	Labor	Misc	R.O.W	C.C
Wellhead	Vassilikos	130	80.74534161	28	$44,885,815.92	$73,300,350.08	$35,847,487.30	$70,857,910.78	$224,891,564.09
Vasilikos	Kyrenia	75	46.58385093	40	$27,204,565.22	$37,534,673.91	$16,120,031.06	$44,433,850.93	$125,293,121.12
Kyrenia	Turkey	90	55.90062112	24	$23,828,108.41	$42,755,482.78	$21,448,706.95	$36,879,728.97	$124,912,027.10
					$95,918,489.55	$153,590,506.78	$73,416,225.30	$152,171,490.68	$475,096,712.31

Upgrate the result										
1	2	3	4	5	6	7	8	9	10	11
2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
$475,096,712.31	$517,825,010.23	$540,609,310.68	$564,396,120.35	$589,229,549.64	$615,155,649.83	$642,222,498.42	$670,480,288.35	$699,981,421.04	$730,780,603.56	$762,934,950.12

Total Investment cost from Wellhead to Turkey $762,934,950.12

Turkey to Ankara

From	To	Appr.(km)	Appr.(mill)	Dia.inches	Material	Labor	Misc	R.O.W	C.C
Bozgazi	Ankara	553	343.4782609	40	$200,365,260.87	$275,576,595.65	$118,252,895.65	$327,370,660.87	$921,565,413.04

Upgrate the result										
1	2	3	4	5	6	7	8	9	10	11
2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
$921,565,413.04	$1,004,447,320.03	$1,048,643,002.11	$1,094,783,294.21	$1,142,953,759.15	$1,193,243,724.55	$1,245,746,448.43	$1,300,559,292.16	$1,357,783,901.02	$1,417,526,392.66	$1,479,897,553.94

Total Investment cost from Wellhead to Ankara $2,242,832,504.06

Wellhead to Mersin- Turkey		Mersin to Ankara	
Investment Cost	$762,934,950.12	Investment Cost	$1,479,897,553.94
Annual Operating Cost Percent	5%	Annual Operating Cost Percent	5%
Operating Cost /Year	$38,146,747.51	Operating Cost /Year	$73,994,877.70
Total Operating Cost from Wellhead to Ankara /Year	$112,141,625.20		

Wellhead to Mersin-Turkey

Titel of Cost	Total Cost	The Amount of Gas That Will Be Issued /1000 Annual	The Amount of Gas That Will Be Issued /1000 PV of 15 Years	Unit Cost /1000 cubic meters	Cost Price /Mcm
Investment Cost	$762,934,950.12		21,127,177.01	$36.11	$48.4
Operating Cost / Year	$38,146,747.51	3,101,981.70		$12.30	
	Gas Price at Wellhead			$121.62	
	Export Price to Mersin			$170.03	

Wellhead to Ankara-Turkey

Titel of Cost	Total Cost	The Amount of Gas That Will Be Issued /1000 Annual	The Amount of Gas That Will Be Issued /1000 PV of 15 Years	Unit Cost /1000 cubic meters	Cost Price /Mcm
Investment Cost	$2,242,832,504.06		21,127,177.01	$106.16	$142.31
Operating Cost / Year	$112,141,625.20	3,101,981.70		$36.15	
	Gas Price at Wellhead			$121.62	
	Export Price to Ankara			$263.93	

	Method One		Method Two	
	Wellhead to Mersin	Wellhead to Ankara	Wellhead to Mersin	Wellhead to Ankara
Investment Cost	$762,934,950.12	$2,242,832,504.06	$1,164,377,354.66	$3,065,829,018.67
Operating Cost / Year	$38,146,747.51	$112,141,625.20	$58,218,867.73	$153,291,450.93
Gas Price at Wellhead	$121.62	$121.62	$121.62	$121.62
Export Price /Mcm	$170.03	$263.93	$195.50	$316.15

Appendix B: Egypt

Wellhead to Egypt										
From		To	Appr.(km)	Appr.(mill)	Dia.inches	Material	Labor	Misc	R.O.W	C.C
Wellhead (Block 12)		Egypt	180	111.8012422	28	$34,168,813.66	$55,749,881.99	$27,262,701.86	$53,945,639.75	$171,127,037.27
						$34,168,813.66	$55,749,881.99	$27,262,701.86	$53,945,639.75	$171,127,037.27
Update the Result										
1	2	3	4	5	6	7	8	9	10	11
2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
$171,127,037.27	$186,517,518.49	$194,724,289.30	$203,292,158.03	$212,237,012.99	$221,575,441.56	$231,324,760.99	$241,503,050.47	$252,129,184.69	$263,222,868.82	$274,804,675.05

Wellhead to Egypt	
Investment Cost	$274,804,675.05
Operating Cost Annual Percent	5%
The Operating Cost /Year	$13,740,233.75

Wellhead to Egypt					
Titel of Cost	Total Cost	The Amount of Gas That Will Be Issued /1000 cubic meters		Unit Cost /1000 cubic meters	Cost Price /Mcm
		Annual	PV of 15 Years		
Investment Cost	$274,804,675.05		21,127,177.01	$13.01	$17.44
Operating Cost / Year	$13,740,233.75	3,101,981.70		$4.43	
	Gas Price at Wellhead			$121.62	
	Export Price to Egypt			$139.05	

	Wellhead to Egypt	
	Method One	Method Tow
Manufacturing Cost	$274,804,675.05	$787,713,002.35
Operating Cost	$13,740,233.75	$39,385,650.12
Gas Price at Wellhead	$121.62	$121.62
Export Price to Egypt/Mcm	$139.05	$171.60