Natural Gas Monetization Approaches: The Case of Cyprus

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ABSTRACT

Natural gas is a highly efficient energy source that tends to increase demand worldwide. One of the most important reasons for this is that it is a clean and environmentally friendly energy source. In addition, ng, which has a wide usage area for transformation sector, such as electricity generation to heating and it has very low greenhouse gas emission. Natural gas in the exclusive economic zone of Cyprus will be ready for production in the coming years. The fact that the amount of natural gas found is above the needs of the island is an important opportunity to export it for the prosperity of the whole country. This shows that the export revenues of the whole island will certainly rise and current account deficits decline. The objective of this thesis is to decide the export routes to be followed by Cyprus in order to monetize the gas reserves and to determine the most cost-effective export option.

To achieve the result, liquefied natural gas (LNG) and pipeline methods, which are the two most important natural gas export options were chosen. Firstly, the cost required to establish a LNG facility was calculated, but it was estimated that it is financially not viable. Later, the pipeline export option was handled and two different routes were envisaged. Briefly these routes are Cyprus-Turkey and Cyprus-Europe.

Finally, it has been decided that the most finacially feasible option in terms of cost of capital expenditures is to divert the pipes to Turkey.

Keywords: Natural Gas, LNG, Pipeline routes, Cyprus, Turkey, Europe

ÖZ

Doğal gaz, dünya çapında talebi artış eğiliminde olan ve verimliliği en yüksek olan yakıtlardan biridir. Doğalgaz enerji üretiminin temel girdisidir. Bunun en önemli sebeplerinden biri, temiz ve çevre dostu enerji kaynağı olmasıdır. Ayrıca elektrik üretiminden ısınmaya kadar uzanan geniş bir kullanım alanına sahiptir. Ayrıca, doğal gaz diğer enerji kaynaklarına göre daha az sera gazı emisyonuna sahiptir. Kıbrıs'ın münhasır ekonomik bölgesinde bulunan doğalgaz kaynakları, önümüzdeki yıllarda üretime ve ihracata hazır hale gelecektir. Keşfedilen doğalgaz miktarının adanın ihtiyaçlarını aşıyor olması, Kıbrıs için önemli bir ihracat potansiyeli yaratmaktadır. Bu rezervin büyük olması, önemli bir fırsat olarak adanın ihracat gelirlerinin artacağını işaret etmektedir. Bu tezin amacı, doğal gazın paraya çevrilebilmesi için Kıbrıs'ın izleyeceği ihracat yollarını belirleyip, finansal olarak en uygun yatırım maliyetine sahip olan ihracat seçeneğini belirlemektir. Yatırım maliyetinin finansal rantabilitesi sayesinde yatırımcıların ihracat seçenekleri üzerinden ya sıvılaştırılmış doğalgaz terminali inşaası, ya da doğalgaz iletim hattı döşenmesi seçeneklerinden birisini seçebilecekleri bu çalışma sayesinde anlaşılmış olacaktır.

Sonuca ulaşabilmek için iki en önemli doğalgaz ihracat yöntemleri olan sıvılaştırılmış doğalgaz (LNG) ve boru hattı (Doğalgaz İletim Hattı) yöntemleri seçilmiştir. İlk olarak, bir LNG terminali inşa etmekiçin gerekli yatırım maliyeti hesaplanmış fakat ortaya çıkan yatırım miktarı yüksek olduğu öngörülmüştür. Daha sonra, boru hattı ile ihracat yöntemi ele alınmış ve iki farklı güzergâh öngörülmüştür. Güzergahlara kısaca değinecek olursak, Kıbrıs-Türkiye ve Kıbrıs-Avrupa olarak belirlenmiştir. Son olarak, Türkiye'ye uzanacak boru hattının yatırım maliyeti

açısından en uygun ihracat seçeneği olacağı sonucuna varılmış ve bu yönde karar verilmesinin finansal olarak daha rantabıl olacağının altı çizilmiştir.

Anahtar Kelimeler: Doğalgaz, Sıvılaştırılmış Doğalgaz, Boru Hattı güzergahları, Kıbrıs, Türkiye, Avrupa

To My Parents and My Fiancee

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LIST OF SYMBOLS AND ABBREVIATIONS

Bcf	Billion cubic feet
Bcm	Billion cubic meters
CERA	Cyprus Energy Regulatory Authority
CNG	Compressed Natural Gas
EC	Estimated Cost
EEZ	Exclusive Economic Zone
EIA	Energy Information Administration
FERC	Federal Energy Regulatory Commissions
GTW	Gas to Wire
IEA	International Energy Agency
IEO	International Energy Outlook
IP	Iran Pakistan
LNG	Liquefied Natural Gas
Misc.	Miscellanies
MIT	Massachusetts Institute of Technology
MTPA	Millions of tons per annum
NG	Natural Gas
NGL	Natural Gas Liquids
OECD	Organization for Economic Cooperation and Development
PGS	Petroleum Geo-Services
ROW	Right of Way
TANAP	Trans Anadolu Doğalgaz Boru Hattı Projesi
TAP	Trans Adriatic Pipeline

TAPI	Turkmenistan-Afghanistan-Pakistan-India
Tcf	Trillion cubic feet
TRNC	Turkish Republic of Northern Cyprus
US	United States
UC ITS	University of California Institute of Transportation Studies
USGS	The US Geological Survey
WEC	World Energy Council

Chapter 1

INTRODUCTION

1.1 General

The share of natural gas in the global energy market has been increasing in recent years. The biggest factor in this increase is that NG is a clean fossil fuel. Natural gas has more than one important features. Physicochemical properties and energy content, enormous worldwide sources, longer life compared to oil production are some of these features. These features made it an alternative fuel.The primary energy used is suitable for the transport and industrial sectors and for power plants. As a result of the estimations made by the US Energy Information Administration (EIA) and the International Energy Agency (IEA), the result is predicted that NG will have the highest increase in claim among fossil fuels by 2035. In addition, worldwide NG consumption tends to increase according to all World Economic Council (WEC) Scenarios. WEC have three scenarios which are connected to climate changes. The common implication for each case was that global NG consumption would increase. However, contribution will be made to climate protection.

The most climate -friendly scenario which is “Unfinished Symphony” sees a recession as of 2050.At the same time, market -driven scenario “Modern Jazz” expect the most elevated gas utilization up to 2060. According to WEC, demand for natural gas over the next 20 years will exceed demand for coal and oil. A large increase in natural gas demand of developing countries is foreseen. A significant inrease is expected especially in the Middle East and China.

In addition, various opportunities in NG agreements, including long-term, short-term contracts and Liquefied Natural Gas spot contracts, have played an critical role in improving the NG position in the energy markets at regional and global levels. New resources were discovered and directed to increase resources quickly. On the other hand, as countries try to maintain their growth rates, demand for energy is increasing rapidly.

It can be said that Cyprus, the inhabitants of the region and neighboring countries' access to gas resources will bring great developments.

1.2 Thesis Objective

The main objective of this study is to analyze the Natural Gas Monetization Approaches in the case of Cyprus. Throughout this study we are aiming to consider the economic implications of key automation and policy options for natural gas improvement in Cyprus. The exploration of natural gas resources in the profound water off the southern shorline of Cyprus has made convenience for natural gas exports and radical changes of the land’s energy system. Briefly, the ultimate aim of this study is to identify the most appropriate target countries for the transfer of NG between Cyprus and new owners of this resources.

This examination tries to give a free and straightforward investigation of choices for Cyprus natural gas resources advancement and exports. It will fill in as an establishment for an essential comprehension by Cypriot decision-makers, the business network, universal and local stakeholders about the key alternatives for using the Cypriot natural gas resources and eventually will give a premise to better basic leadership.

1.3 Thesis Organization

Chapter 2 shows the NG position in the World, Cyprus and the Middle East. Important information in this study, such as natural gas reserves, demand, production and consumption in these countries and in the world has been disclosed.

LNG and pipeline systems are explained in Chapter 3, which also describes how those two systems work and their features. In addition to that, the cost of the LNG system for Cyprus is also calculated.

Chapter 4 refers different routes for the natural gas pipeline of Cyprus.Besides that, it also contains information and computations on pipeline investment costs.

Lastly, the Conclusion and Policy recommendations are explained in Chapter 5.

Chapter 2

AN ANALYSIS OF NG RESOURCES IN CYPRUS, MIDDLE EAST AND REST OF THE WORLD

2.1 NG Resources

NG is a fossil fuel type that results from exposure of dried animals and plants to powerful heat and pressure for more than a thousand years. Natural gas is a fossil fuel that has great importance in terms of economic and environmental benefits. Nevertheless, access to the natural gas resource requires great economic resources. So it directly affects the economy. So, the mechanism of extracting, transferring and finding a applicable market for this type of energy is an important issue in the world.

2.2 NG Demand and Consumptıon in the World

2.2.1 History of NG

Although natural gas has been known since ancient times, its commercial use is relatively new. China started to use raw bamboo "pipelines around 500C to transport seepage gas and boil seawater to obtain potable water.

The first commercial natural gas occurred in the UK. Around 1785, the British used natural gas produced from coal to light houses and streets. In 1816, Baltimore, Maryland used such natural gas to make it the first city in the US to illuminate its streets with gas. In 1821, William Hart excavated the first successful NG well in Fredonia, New York, USA. Eventually Fredonia Gas Light Company was founded and became the first American natural gas distribution company. More than 900 public gas systems in the US today and the largest and longest-running public gas system in the US at Philadelphia Gas Works. Throughout the 19th century, natural gas was used purely as a light source. However, the invention known as Bunsen burner by Robert Bunsen in 1885 opened enormous new doors for using natural gas. When effective pipelines began to be established in the 20th century, the spread of NG to appliances such as domestic heating and cooking, water heaters and ovens, production and processing plants, and boilers for generating electricity.

2.2.2 NG Demand and Consumptıon in the Rest of the World

Global NG consumption is projected to rise from 120 Tcf to 203 Tcf in 2040 in the International Energy Outlook 2016 (IEO, 2016). Natural gas as energy source constitutes the largest increase in the world primary energy consumption. Natural gas remains a key fuel in the electricity and industrial sectors. In the energy sector, natural gas is an attractive choice for new production facilities due to its fuel efficiency. NG is also cleaner than products such as oil and coal. Many countries in the world have started to implement national or regional strategies to diminish CO2 emissions. In line with these plans, incentives to natural gas tend to increase compared to other energy sources, such as, coal or oil. Utilization of NG increments in each IEO locale, with request in countries farther the non-OECD expanding more than two times as quick as in the OECD. The most grounded development in NG utilization is anticipated for the nations of non-OECD Asia. In the country, financial development prompts expanded claim. NG utilization in the non-OECD district develops by a normal of 2,5 percent year from 2012 to 2040, contrasted and 1,1 percent per year in the OECD nations. Accordingly, non-OECD nations represent 76 percent of the complete world augmentation in flammable NG consumption, and a lot of world NG use develops from fifty two percent in 2012 to sixty two percent in 2040.

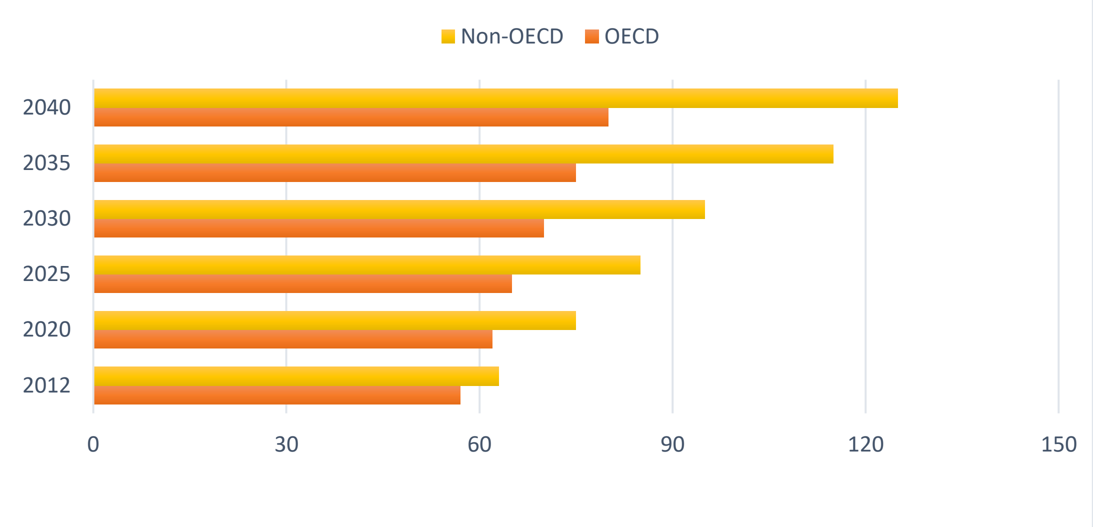

Figure 2.1: World natural gas consumption, 2012–40(trillion cubic feet)
Source: U.S. Energy Information Administration | International Energy Outlook 2016

Table 2.1: Energy Consumption in the World, 2008-35

World Energy Consumption, 2008-2035	Annual Average % change
OECD	0.6
Non-OECD	2.3
World	1.6

Source: Energy Information Administration, World Energy Outlook, 2011.

To meet the increasing demand for NG foreseen in the quotation example, the world's natural gas producers are increasing their supplies 69% from 2012 to 2040. The highest increment in NG production from 2012 to the end of 2040 occurred in Asia. This increase corresponds to approximately 18.7 Tcf. In addition, Asia is followed by the Middle East (16.6 Tcf) and OECD America (15.5 Tcf). Only in China, as the country rises the development of shale resources, production increases by 15.0 Tcf. NG production growth in the USA and Russia is reported as 11.3 Trillion cubic feet and 10.0 Trillion cubic feet. The increase in production in the USA comes mainly from shale sources. China, USA and Russia provide approximately forty-four percent of the natural gas production increase in the world.

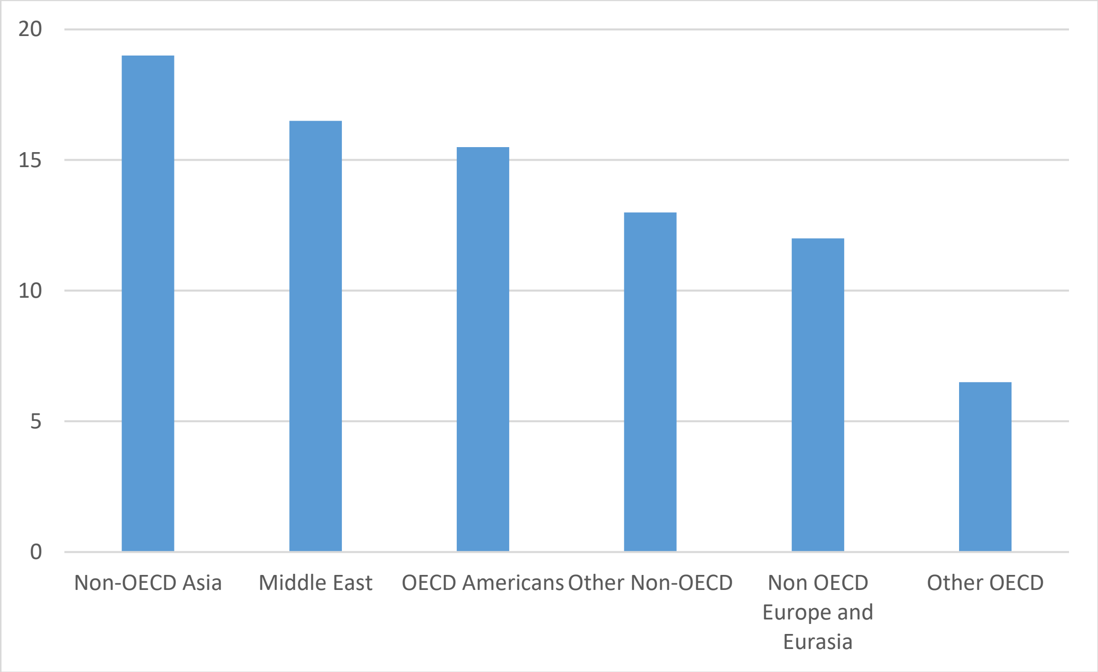

Figure 2.2: World increment in NG production, 2012–40 (tcf)
Source: EIA, International Energy Outlook 2016

2.2.3 NG Usage Accordıng to the Sectors

Based on the information in Energy Outlook 2035, we can say that more than 80% of the total claim increase is due to the increased consumption of the sectors. As the globally expanding natural gas consumption rate is 75 bcf per day and 2.3 percent per year, expectations are due to the increasing use of the industry.

With the extra interest of gaseous petrol by generating station and the industrial sector, there will be fifty bcf per day in non-OECD countries, and the growth in the power plant and industrial segment in OECD countries will be 25 to 12 bcf per day. The transportation industry, which will constitute 3% of the all NG consumption by 2035, can also be defined as the fastest growing sector.

The figure below shows the distribution of world natural gas use on a sectoral basis.

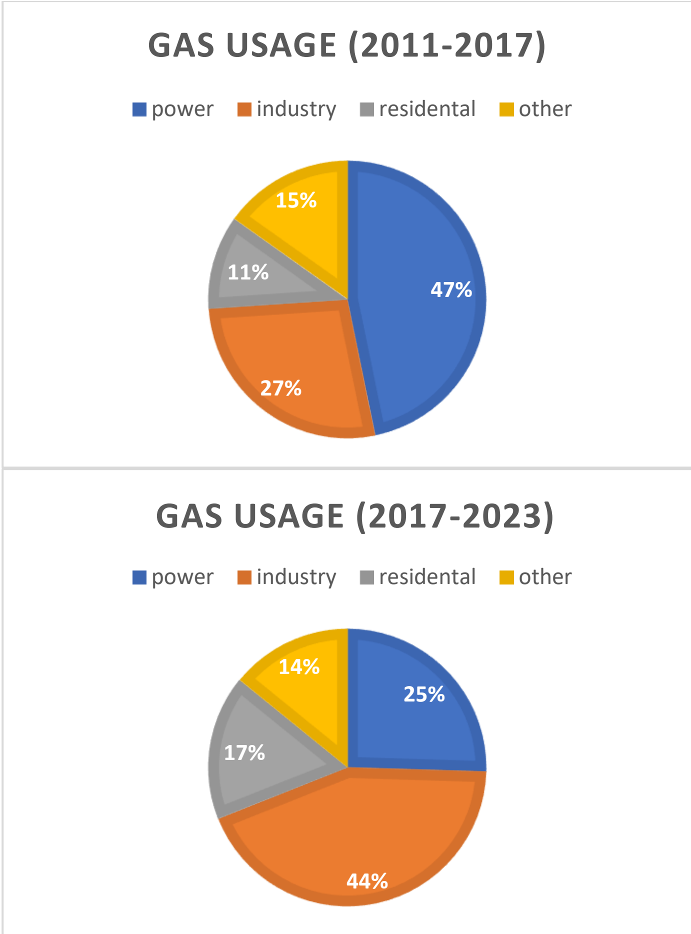

Figure 2.3: Usage of gas in different sectors
Source: Analysis and forecasts to 2023, GAS 2018, IEA (2018)

2.2.4 NG Proven Reserves

As announced by the Statistical Review of World Energy approximately 196.9 Tcf of NG is accessible as proven reserves, which are accessible in the world (BP-statistical,2019).

Table 2.2: Proven NG reserves by major regions in the world.

NATURAL GAS PROVED RESERVES						
Location	At end of 1993	At end of 2003	At end of 2012	At end of 2013	At end of 2018	Share of Total
Total North America	8.8	7.4	11.1	11.7	13.9	7.1%
Total S.& Cent. America	5.4	6.8	7.7	7.7	8.2	4.2%
Total Europe & Eurasia	40.5	42.7	56.5	56.6	66.7	33.9%
Total Middle East	44.4	72.2	80.3	80.3	75.5	38.4%
Total Africa	10	13.9	14.5	14.2	14.4	7.3%
Total Asia Pacific	9.3	12.7	15.2	15.2	18.1	9.2%
Total World	118.4	155.7	185.3	185.7	196.9	100.0%

*The unit of measurement is Trillion cubic meters
Source: (BP-statistical,2019) Statistical Review of World Energy

Table 2.2 shows the quantities of gas reserves in major parts of the world from 1993 to the end of 2018. An important conclusion that can be drawn from the table is that the amount of NG resources in the world has increased by nearly 66% in the last two decade. World's largest ranking gas reserves at the beginning of 2019 Russia, Iran and Qatar respectively (BP-statistics, 2019).

2.3 NG in the Eastern Mediterranean

Cyprus, Turkey, Israel, Egypt, Jordan, Lebanon, Syria and Palestinian are the countries of the Eastern Mediterranean. With the predicted economic improvement and the population of the region, the energy demand, which is expected to increase from 45.3 million in 2010 to 58 and then up to 62 million in 2030, should increase significantly in the next twenty years. Although current consumption levels are preserved, regional oil and gas reserves will remain unsustainable in the next twenty years. Fortunately, the overseas Levant Basin, especially new explorations of huge hydrocarbon resources, have significantly changed supply-side forecasts for the region. Thanks to these explorations, increasing trend in the region can be met. It also has the potential to close the lack of exports.

Problems arising in the region may negatively affect the speed and success of the changes to be made. Physical and economic security are among the most important issues in the region. These are the biggest factors that will affect offshore hydrocarbon development and the energy sector in the region. Crisis in Syria and Egypt and regional disagreements between some countries in the Eastern Mediterranean will affect regional energy production, consumption and trade. Moreover, negative economic developments in the region affected by the Cyprus debt crisis and civil war in Syria may affect claim, production and trade negatively. However, it may threaten the realization of energy infrastructure projects that are likely to be realized. Overcoming these challenges will determine the region's energy future.

The hydrocarbon sector began to develop when oil exploration began in Syria, after 80 years ago in the eastern Mediterranean, following achievements in neighboring countries such as Saudi Arabia. Until the early 1960s, significant commercial oil production did not start in Syria. Therefore, oil research actions in

Israel and Jordan showed a huge increase between 1960 and 1970. Despite this, both countries remained behind Syria. However, very low levels of production continue in Israel and Jordan. Syria and Israel are also NG producers, but these sectors haven't developed economically till the 1980s in Syria. Also, in Israel in the 2000s. Since the 1980s, Jordan has been at very low levels compared to the region in which it produces oil and natural gas. For this reason, Jordan relies on imports to meet domestic claim. In Cyprus, oil investigation and advancement in the Lebanese and Palestinian Territories is still in its early stages, however each plan to put resources into effective abroad investigation in the Levant Basin to create nearby flammable gas assets.

Energy resources transportation works have been going on for decades in the Eastern Mediterranean region. Even in the Eastern Mediterranean countries, specially before the start of its oil and NG operations in the 1960s and 1970s. It has often benefited from transport fees paid by nearby exporters such as Syria, Iraq and Saudi Arabia. In recent years, a significant increase has been observed for exploration and new projects. However, the international transition has not ceased to be the main policy assessment of some Eastern Mediterranean countries. If research and development of hydrocarbon resources in the region continues, the region will increase the pressure to be seen as an important energy center.

2.3.1 Levant Basin

Covering most of the offshore areas of the Eastern Mediterranean, Levant Basin has become the hub of the latest energy discoveries in the region. In the report published in 2010, the USGS stated that the Levant Basin had more resources than the discovered amount. The estimated amount corresponds approximately to 122 Tcf. In this context, it was revealed that the combined oil reserves are over 2.5 billion barrels and 60% of this belongs to Syria. In addition, the estimated natural gas reserves have been shown to be 18.2 Tcf.US Geological Survey also estimated the possible unexplored sources of natural gas liquids to be 3.1 billion barrels.

US Geological Survey does not have estimations that reflect all of the potential energy resources of the Eastern Mediterranean region. However, we can say that the Levant Basin represents an important part of the general resource base.US GS estimates that if discovered, it will increase the proven reserves of the region to just under 70 percent, while it estimates 1.7 billion barrels of oil, while 122 Tcf shows more than 6 times the region's existing reserves. In addition, if current consumption levels continue for approximately 20 years, 1.7 billion barrels of oil can meet regional demand, and more importantly, 122 Tcf NG can meet ongoing regional claim endlessly. Practically entirety of the ongoing disclosures in the Levant Basin were gaseous petrol, and seaward explorations could ultimately produce recoverable amounts of oil, but there have been no commercially discoveries to date.

2.3.1.1 Offshore Exploration and Discoveries

We can show the recent developments in the Levant Basin as the most important reason for the great change of energy appearance in the Eastern Mediterranean. Accomplishment in Cyprus, Israel and Palestinian led to further research in the region.

Almost all of the major NG fields explored in the last decade were in the Levant Basin. There has been important exploration in the Cyprus and Palestinian regions, but most are in the territorial waters of Israel. The discovery continues in Lebanon and Jordan, but as of June 2013 there has been no major commercial discovery. Syria, the government and the opposing forces, which were previously the region's primary hydrocarbon producer, continue. Although Cyprus, Israel, and to a lesser extent, the successes of the discoveries in the Palestinian Territories have shown that it has a good potential in the Eastern Mediterranean, especially in terms of natural gas production. Important discoveries, Noa (1999), Mari-B (2000), Dalit & Tamar (2009), Leviathan (2010) and Aphrodite & Tanin (2011), respectively, justified the natural gas expectations of the US Noble Energy. The greatest sea exploration in the Eastern Mediterranean is the Leviathan area, estimated at 18 Tcf in recoverable resources, about 80 miles off the offshore Israeli coast and at a depth of about 5,000 feet. As some estimates indicate that the site may contain 600 million barrels of oil, in 2013 exploration oil wells drilled under the Leviathan gas field, once offshore.

Another critical Israeli discovery, Tamar field, started activities in April 2013. Then, Dalit and Tanin fields should come accessible at some point in the following decade. Ongoing amendments to asset gauges for the Tamar field carried the evaluated retractable stores to 10 Trillion cubic feet, enough to meet today degrees of Israel's interest for quite a long time. The Tamar field began generation in a shockingly brief timeframe, with under five years between the disclosure and economically suitable creation.

Another potentially important finding in the Levant Basin is the Aphrodite-2. Likewise, investigation in region straddling the sea limit among Israel and the Palestinian demonstrates that there are possibly noteworthy amounts of natural gas in the region. Israel's Meged wells (coastal) and Noa field (seaward) demonstrated guarantee not long ago, and both are near the accepted Israel-Palestinian Territories limit. In 2004, the Meged area found by Givot Olam Petrol has more than 10 million barrels, according to the results shown. It can also reach Palestinian territory

The Lebanese government submitted pre-qualification in April 2013 for search in the country's territorial waters. The official licensing tour started in May 2013 and the tender must end at the end of November 2013 with the rewards declared in February 2014.

Early estimates of Lebanon's offshore reserves are 25 Trillion cubic feet NG resources in the offshore zone. According to the results of early seismic studies, the sources located in the south of the exclusive economic zone of Lebanon are estimated to be a total of 12 Tcf. However, more studies should be done to confirm these estimates.

Due to the ongoing civil war in Syria, energy exploration activities have almost come to a halt. A bid tour for offshore blocks was concluded in 2011. However, the government delayed the rewards due to the country's troubles. However, as long as the current conflict continues in the country, it is not possible for additional offer tours to take place. After major postponements, blocks finally entered the tender in December 2011. However, as of July 2013, Syria had not announced its results. Syria, the country's overseas research in the country in April on further research, especially with Russia and China reportedly held talks with international partners in 2013, but the details remain few.

2.4 NG in Cyprus

During the geophysical and geological studies carried out by the Iraqi Oil Company on the island between 1938 and 1948, the first hydrocarbon discovery in Cyprus was made. Between 1949 and 1970, four wells were discovered at a depth of 1,250-3,295 meters. But after the local company drilled, the wells named Tseri, Moni, Archangelos and Lefkoniko turned out to be dry.

Since 1970, research has been initiated on marine and shallow waters up to two hundred meters by different firms and institutes.

2.4.1 The Aphrodite Gas Discovery

In the early 2000s, Republic of Cyprus, which represents only Greek Cypriot population, used the Norwegian (PGS) company for primary research in the early 2000s to determine the hydrocarbon potential of Cyprus through seismic surveys, in other words, to determine whether it was appropriate to pursue it much more costly. Intuitive sounding, the firm proved the results were very positive, the Greek government of Cyprus issued exploration and production license tenders for 11 sea blocks in February 2007. For as much as only three mid-size organizations took an interest in the offer so they allowed a permit to Nobel Energy, in October 2008.

In late 2011, Noble Energy declared the exploration of the Aphrodite NG field in Cyprus exclusive economic zone and uncovered a evaluated net asset scope of 5 to 8 tcf, whit a gross mean of 7 trillion cubic feet. Noble Energy works the disclosure with a 70% working intrigue; while Delek Drilling and Avner Oil Exploration each hold 15 percent stakes. The Aphrodite field is a seaward gas field off the southern coast of Cyprus found at the exploratory drilling Block 12 in Cyprus'EEZ. It is worth to note here that the Greek Cypriot Administration has unilaterally declared Cyprus EEZ, which is not recognized by Turkey and the TRNC (represented by Turkish Cypriot population). Several notes were given to the UN to condemn the EEZ of Cyprus, which is overlapping with the one with TRNC's and Turkey's EEZ. This has created a political dispute between Turkey and the Greek Cyprus Administration, where monetization of Cyprus hydrocarbons will not be possible unless disputes are politically resolved. Fruitful explotary drillings seaward neighboring Israel empowered the conviction that Aphrodite could in fact hold significant measures of gas, approximately 5 trillion cubic feet.

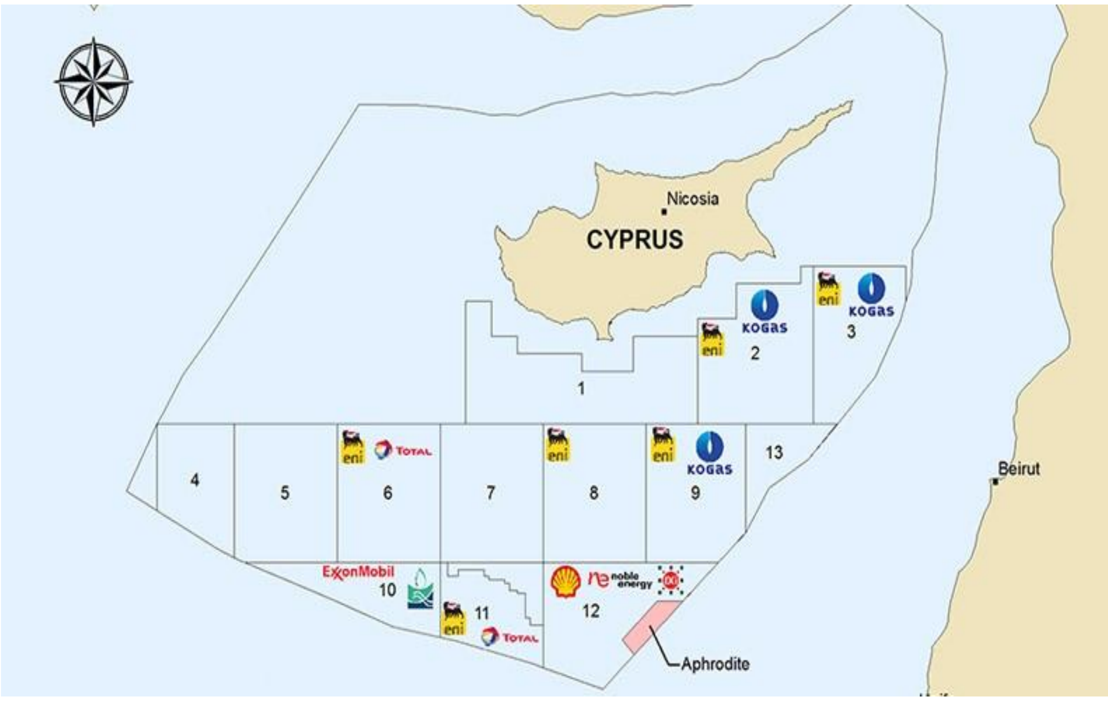

Figure 2.4: The EEZ in Cyprus
Source: Cyprus Hydrocarbons Company, 2019

The self-declared Cyprus' Exclusive Economic Zone covers an area of approximately 51,000 km and is also divided into 13 offshore blocks.

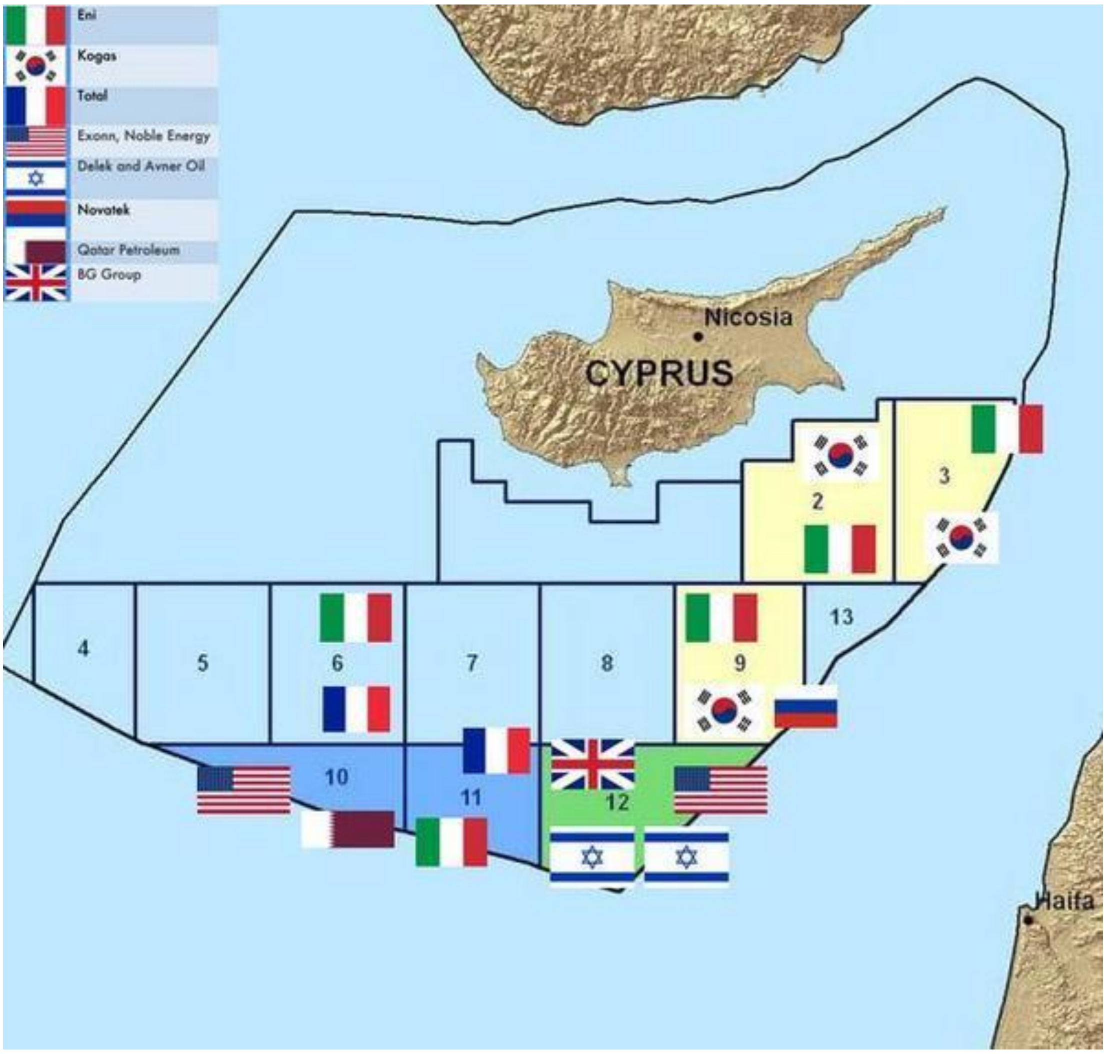

Figure 2.5: Cyprus' Exclusive Economic Zone and drilling licenses issued to International Energy Companies
Source: Andreas Vou, VoxEurop, 2018

The first study representing Block 9 is considered to have the greatest capacity among other blocks in Cyprus. Essentially, it is twice as high as the gas capacity in Aphrodite (Giamouridis, 2013). The reason for this is the proximity of block 9 to the Levant basin.

Geographically, the Levant basin is located to the east of the Mediterranean Sea. Cyprus, Israel, Palestine, Lebanon, Syria and Turkey, like many countries, the Levant basin is shared with each other. This is shown in the next figure.

Figure 2.6: Levant Basin
Source: Eastern Mediterranean Region, EIA,2013

According to the USGS and EIA, Levant Basin has approximately 1.7 billion barrels of oil storage and 122 Tcf NG (USGS, 2010). Therefore, it may affect the amount of NG to be discovered in Cyprus.

2.4.2 The Calypso 1 Discovery

At the beginning of 2018, Eni has made a lean gas disclosure in Block 6 Offshore Cyprus with Calypso 1 NFW. The well drilled at a depth of 2,074 meters, reaching a total depth of 1,874 meters, encountered a long gas column in Miocene and Cretaceous rocks. The Cretaceous sequence has excellent reservoir properties. Intense and detailed data collection (liquids and rock samples) was performed on the well. The estimated amount of natural gas as a result of these approximately 5 trillion cubic feet.

ENI Blok 6 is the operator and has a 50% shareholding, while TOTAL is a partner with 50%. ENI has been in Cyprus since 2013 and is interested in six licenses. In Cyprus EEZ (Blocks 2, 3, 6, 8, 9 and 11), five of them are operated.

2.4.3 The Glafcos (Glaucus) Discovery

In the first quarter of 2019, ExxonMobil declared the exploration of the Glafcos NG field in Cyprus EEZ, based on preliminary interpretation of the well data the discovery could represent an in-place natural gas resource of approximately 5 trillion to 8 trillion cubic feet. Glafcos was the second of a two-well drilling program in Block 10. The first well, Delphyne-1, did not encounter commercial quantities of hydrocarbons. ExxonMobil Exploration and Production Cyprus (Offshore) Limited is operator and holds 60 percent interest in the block. Qatar Petroleum International Upstream holds 40 percent interest. The Glafcos gas field is located in offshore Block 10 south-west of Cyprus in the Eastern Mediterranean, which is adjacent to Egyptian mega reserve Zohr (which is only 10km away from Egyptian gas reserve). Further evaluation of Block 10 potential continues.

Cyprus is the third largest island in the Mediterranean, located near Africa, the Middle East and Europe. For this reason, it’s a strategically important advantage in reaching larger market alternatives. Furthermore, this revelation will be unreasonably significant for the whole island (if the issues will be understood between two sides). It will get autonomous in the Natural Gas, adjacent to, it can show up as an exporter in the market. This fare will create pay and addition in the Gross NP that will prompt the guarantee of strength in the nation against money related emergencies.

The capacity to make an early search in Cyprus is about 20 Tcf, but there is some ongoing research and it is expected that this number will increase significantly, as 13 blocks have not yet been discovered. However, if supported by smart decisions, the export option may be useful. However, the methods of natural gas exports are examined under three main headings, but each should be examined and decided in order to follow a wise path. We will clarify this in the following sections.

2.4.4 Natural Gas Demand in Cyprus

Energy Information Admiration document demonstrates that approximately 60,000 barrels of oil are transported to Southern Cyprus per day (EIA, 2012). In more detail, it should be known that an oil drum corresponds to 6000 cubic meters of NG. It would not be wrong to estimate that gas consumption can be approximately 80,000 barrels of oil per day. 480 million cubic feet of natural gas per day.

However, two important factors need to be considered in order to provide a document on the exact claim rate of NG in Cyprus; The first is to determine how much of the economic structure on the island will be transformed or depend on gas, and the second is the possibility that Cyprus will come together, as well as affect both reasonable and direct expenditure on demand.

The most important issue is how to connect these natural resources owned by the island to the markets. There are a number of solution opportunities, which are Pipeline, LNG, CNG and GTW. Let us now look at how these elements work and which option is more logical, and reliable to monetize natural gas in Cyprus.

Chapter 3

EXPORT OPTIONS OF NATURAL GAS

There are three main opportunities for natural gas trade in front of the Republic of Cyprus. These options are exported respectively in liquefied natural gas (LNG) processed form, as Compressed Natural Gas (CNG) in semi-processed form or in pure form through a pipeline. Every one of these alternatives has its favorable circumstances and drawbacks. This study does not provide a comprehensive feasibility report. However, in the following sections there are also estimates for the cost of LNG and pipeline.

3.1 Liquefied Natural Gas Method

3.1.1 Liquefied Natural Gas

LNG is a natural gas converted into a liquid form for the convenience and safety of NG transportation. The type of natural gas called LNG must first be cooled down to -260 F (minus 160 celcius). As a result of this process, a clean and non-toxic liquid is produced which can be transported. This liquid-shaped natural gas can easily be exported to regions where natural gas is scarce.

In liquid form, the NG occupies 1/600 of the area, i.e. the natural gas shrinks 600 times, which makes shipping and storage much easier when the pipeline cannot be carried. According to the researches, there is a positive relationship between the world consumption and the importance of LNG trade. In other words, as the consumption in the world is constantly increasing, the importance of LNG trade will increase.

3.1.2 Working principle of Liquefied Natural Gas

The purpose of LNG is to move NG from one resource to another. Exporters use this method to send to different countries and countries where pipelines are not available. Liquefaction of natural gas in large scales has two main approaches.

a) The Linde Method

b) The cascade processes

Natural gas is primarily liquefied. After this process, it is saved in specific tankers and exported to the target. LNG is not likely to explode if there is any leakage or spillage. After the LNG is delivered, NG is allowed to re-expand and gasify, this process is known as regasification. After re-gasification, natural gas is distributed to consumers through pipelines.

3.1.3 International Demand for Liquefied Natural Gas

Although it has one of the world's largest natural gas reserves, the US imports a small percentage of its NG from France and Trinidad as liquefied natural gas. Actually, as of 2019, the U.S. was the 3rd largest exporter of Liquefied Natural Gas, and by 2024 it is expected to surpass Australia and Qatar and become the largest exporter.

The biggest importers of the USA are shown as South Korea, Mexico and Japan. The expected increase in demand in Asian countries is that in the near future, energy will be directed to LNG instead of coal.

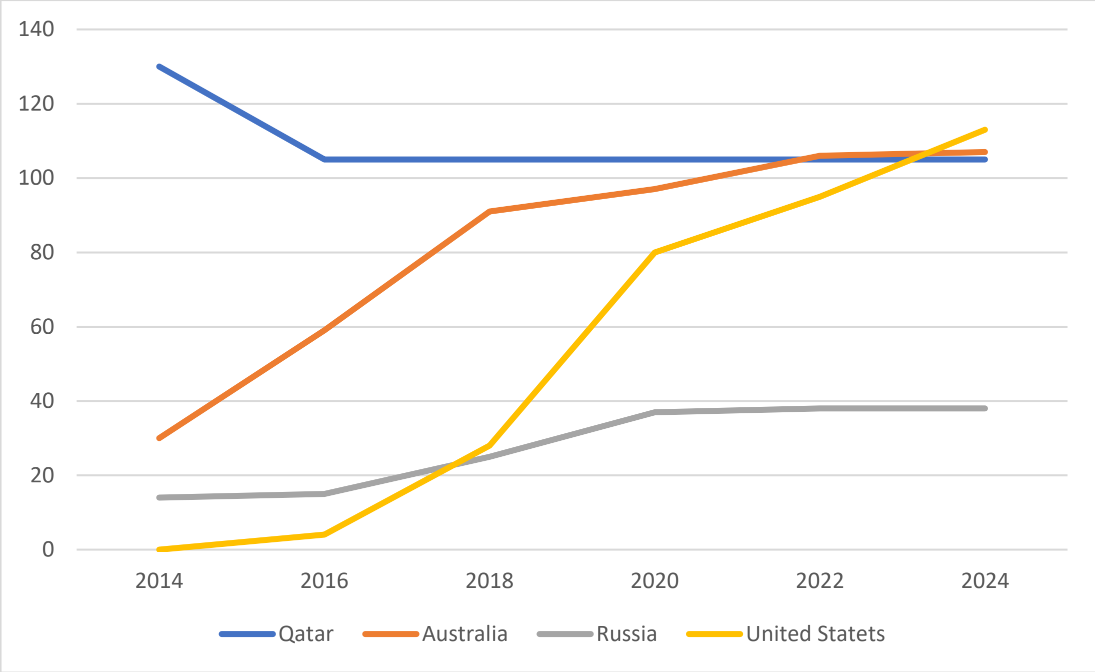

Figure 3.1: LNG exports for a selection of exporters, 2014-2024
Source: Analysis and forecasts to 2024, GAS 2019, IEA

The remaining leading exporters of LNG include Indonesia, Nigeria, Russia and Malaysia. Countries with the world's biggest NG resources are Russia, Iran and Qatar, respectively. As of 2019, it is not surprising that China is the world's largest importer of NG, primarily with increments in LNG purchases.

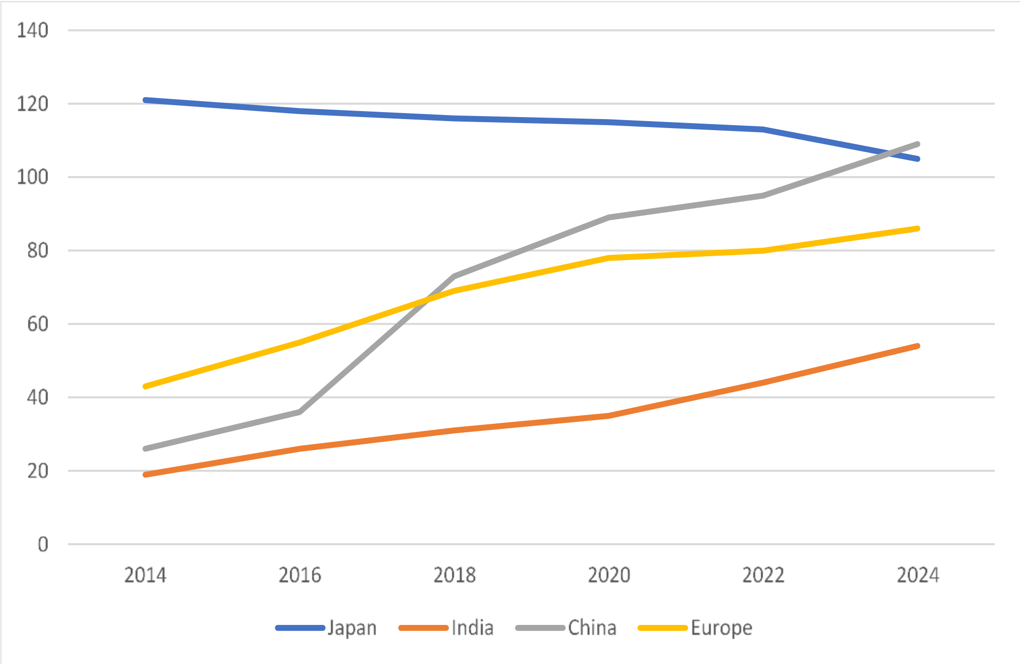

Figure 3.2: LNG imports for a selection of importers 2014-2024
Source: Analysis and forecasts to 2024, GAS 2019, IEA

3.1.4 Advantages and Disadvantages of Liquefied Natural Gas (LNG)

The most important advantage of LNG with respect to export with the pipeline method is that it can export to any part of the world. In theory, at least, it does not depend on a single buyer, but LNG is usually sold under long-term contracts. Moreover, Asian market, which is growing faster than the EU natural gas market, will have better expectations than pipeline gas in the long run if this does not break this line.

A second advantage is that LNG production is probably less defenseless to the attacks of militant groups than a long pipeline, since it occurs in single place. LNG's last big attraction is that it is 600 times smaller in volume than NG. This feature, which always allows large quantities to be exported, also reduces shipping costs.

Despite all this, we can list four major problems with an LNG facility. The first is the huge operating and investment cost, which significantly diminishes the revenue that can be generated. In the next section, estimates and calculations related to them will be discussed.

3.1.5 Analysis of LNG as a Gas Monetization Pathway for Cyprus

In this section, the cost estimate of establishing an LNG facility for Cyprus will be displayed using the data from the plot Aphrodite (Block 12). It will also be referred to its return.

Finding an important gas resource in the Cypriot EEZ is a potentially transformative economic opportunity for the Republic of Cyprus. However, assuming that the Cyprus energy system will go to a significant degree of gasification policy in the future. Due to the limited domestic demand that needs to be taken into account, the economic potential of the resource cannot be fully revealed. To reveal this gas potential, it will be necessary to turn to foreign markets. As explained in the introductory descriptions, there are a number of options for delivering Cypriot gas to foreign markets. In this chapter, the economy of the LNG export route is being explored.

The amount of gas to be determined for export will primarily depend on how much NG is used for domestic consumption. For now, we can say that it is not very common in domestic consumption. However, the Cyprus Energy Regulatory Authority (CERA) estimates domestic consumption as approximately 25 bcm by 2035. In the light of this information, we can say that the amount of gas available for export will decrease from 198 bcm to 173 bcm. For instance, LNG production is an energy intensive process, so a large amount of gas is used to produce the power required to produce the product. It is also priced variously.

Table 3.1: Amount of gas available for export in Aphrodite (Block 12)

TOTAL AMAOUNT OF GAS AVAILABLE FOR EXPORT	
Gross mean estimate for gas in Block 12, tfc	7.0
Gross mean estimate for gas in Block 12, bcm	198
Domestic consumption at 1bcm per year	25
Gas available for export before investment, costs and transit loses, bcm	173

Source: The Cyprus Hydrocarbones Issue: Contex, Positions and Future Scenarios. Gürel, A., Mullen, F., & Tzimitras, H. (2013)

After the consumption of the island itself is reduced, a new amount of LNG power consumption will emerge. The estimates of authorities in the business world range from 5 to 20%, so the gas consumption of the LNG plant was estimated at 12.5%. This reduces the gas offered for sale to 152 bcm. We can estimate the total investment cost of LNG after three digits.

I) Cost of exploration (estimated derived from Noble investment in 1 year):

The cost of exploration and development wells is another important cut. Using the search cost reported by Noble Energy in Cyprus and Israel in 2011, we made a harsh estimate of the exploration cost of about $ 200 million. More research is needed before Block 12 can fully reveal its reserves, so we've multiplied annual research spending by three to $ 600 million.

II) LNG construction cost:

The next substantial investment cost is estimated by the Republic of Cyprus to be 7 to 10 billion euros or $ 10 billion at medium range. This cost represents the construction of a single-train LNG facility. This estimate has been reached using the Republic of Cyprus Trade Minister and the general LNG facility cost calculation method. In more details;

Constructing an LNG plant costs at least $1.5 billion per 1 MTPA capacity and the current plan of Republic of Cyprus is to build a single-train plant of 5 million tons per annum (MTPA). When we take the necessary actions, we encounter between €7 and €10 billion.

III) Submarine pipeline cost to be built between the source well and Vassilikos:

As calculated in chapter 4, the cost of this pipeline is approximately $ 1,054,772,701.

As a result of all these estimates and calculations, the total investment cost is approximately 11 to 12 billion dollars. These processes are tabulated in Table 3.2.

Table 3.2: Total Investment costs of LNG

Cost of exploration, $ million	$600
LNG construction cost,mid-range, $million	$10,000
Distance from Block 12 to Vassilikos, km	130
Cost of submarine pipeline from Block 12 to Vassilikos, $ million	$1,054
Total investment cost of LNG, $million	$11,654

Source: Authors own calculations and The Cyprus Hydrocarbones Issue: Contex, Positions and Future Scenarios. Gürel, A., Mullen, F., & Tzimitras, H. (2013)

3.2 The Gas Pipeline Method

3.2.1 The Gas Pipeline

The pipeline gas transport system has two main models, according to the way it is built, and location. The pipeline constructed above or below the earth is illustrated as a terrestrial pipeline. Another one of the two main model is also well-known as submarine or onshore pipeline gas transportation system. In addition to the second model, it can be said that the entire piping system and part of it floats in water.

The pipeline gas transport system is used to deliver gases and liquids to the specified destinations from their source. The structure of the material has the ability to shape the design and installation of the pipeline. We can categorize pipelines on the condition that there are 3 different types. These are classified as steel, collapsible plastic and composite pipelines. The pipeline has proven to be a safe natural gas transport system.

Offshore pipeline system used for hazardous material transfer will be in this study. Therefore, to make it more understandable how the system works and what it is, briefly mentioned the installation methods.

The most important part of the construction of the onshore gas pipeline is a unique set of equipment vessels produced for this job. There are two ways to set up this system. The first step is to get the pipe ready on the deck. Secondly, it must be placed on the seabed with the moving ship. This process is illustrated as follows.

Figure 3.3: The procedure of installment and laying the pipeline offshore

Besides, it is building the funnel on the board before fitting it on the seabed and after the establishment the channels are conveyed by vessel in the ocean. Depending on the location of the pipeline, the pipe can be placed ashore. The next figure is sufficient as an example of operations on land. It can also be placed on the seabed after the operations on land are finished.

Figure 3.4: The procedure of the pipeline installment onshore

3.2.2 Pipeline Characteristics

Offshore NG pipeline has 2 main circumstances: diameter and strength. Pipeline diameter may vary depending on the characteristics of the lines. For example, for a large-capacity line, the diameter starts at 76 millimeters or 3 inches, 1,800 millimeters, or 72 inches. The strength of the pipe wall normally starts from the lowest level of 0.39 inches to the highest thickness of 3 inches (Gerwick, 2007). Diameter and wall stoutness have different dimensions, helping the pipeline engineer to ensure the perfect pipe designs to transfer the liquid and gas to be transported in the system despite tremendous pressure and temperature.

In this study, pipeline diameter assumptions are 24 and 28 inches for offshore. Also, 40 inches for land. The size of diameter was determined using the reports submitted to TRNC (Pourbozorgi, 2014).

3.2.3 The Cost of Pipeline

NG pipeline cost is separated into four classifications, consisting of material, workmanship, diversity and right of way. Materials and workmanship are the most significant parameters. These factors cover nearly 80 percent of the total investment cost. The right to cross (ROW) is the right to make a road on a piece of land that usually goes to another piece of land. It is also a legal right determined by the owner.

Finally, some factors will be affected by the gas pipe diameter, location, rules and similar costs during the gas pipeline construction process. In general, the increase in pipe diameter in the pipeline system automatically affects the cost per mile positively. That is, the construction cost will increase as the diameter increases. It is important what is on the route of the pipeline. For example, if it will pass through residential areas and highways, capital costs will need to be increased. Business and tax rules differ from country to country. As a result, cost calculations may show increases or decreases.

Whichever method we use, the most important factor in estimating or calculating pipeline cost is that we have the cost per kilometer. Oil and Gas Magazine collected data between 2015 and 2016 to present to FERC. In the light of these data, one kilometer of onshore pipeline showed that the operating cost was $ 7.65 million per mile. One mile is approximately 1.60 kilometers. For this reason, operating costs incurred $ 4.78 million (cost of running a km of onshore). To determine the cost per mile of an NG pipeline, it must first be calculated in inches per mile. This is done by multiplying the distance of the pipe by the diameter of the pipe. For example, a 30-inch diameter pipeline will cost less than a 36-inch diameter pipeline. According to NaturalGas.org (The Oil and Gas Journal compiled the data ,2016 and Natural gas.org), the average diameter of an interstate pipeline is between 24 inches and 36 inches, or an average of 30 inches. If you divide the cost of running a km of onshore which is $4.78 million per km by the 30-inch average diameter, you'll find that this puts the average cost per km of NG pipeline construction at $159,375.00 per inch of diameter. This cost applies to the onshore pipeline. As shown in the next sections, the cost of the onshore pipeline is almost fifty-five percent of the cost of the offshore pipeline. In this case, the worth of the offshore pipeline per inch of diameter would be approximately $ 289,772.72. Both costs include Material, Labor, Miscellaneous costs and Right of Way.

Table 3.3: The cost of pipeline per km

Investment Cost per length (km) /Diameter (inch)	Onshore pipeline	~$159,375.00
	Offshore pipeline	~$289,772.72

3.2.4 The Construction Cost

Construction costs often depend on the location of the project. Accordingly, the estimated cost of the pipelines cannot be precisely calculated. Because it is not possible to find a formula that can be used continuously according to any location or situation. So, there is no exact construction cost.

Nathan Parker, has published an article showing the formula and approach to best estimate the cost of NG pipeline construction. Nathan describes a formula for pipeline construction cost as the passive estimate equation (Parker,2004). The cost resulting from this approach is below the estimated cost in this study. Details of this approach are shown in the Appendix.

In order to decide on the cost of development, the costs of projects in the Middle East and Asia were used. First one is the natural gas pipeline system between Afghanistan, Pakistan, Turkmenistan and India, which has a length of 1735 kilometers under the name TAPI. Secondly, the natural gas pipeline examined is the IP found between Iran and Pakistan, whose length is 2775 kilometers. TANAP, which has recently participated in the practice, has a length of 1841 kilometers. This line combines the two continents starting from Azerbaijan via Turkey to Europe. Next, the data is treated as four categories with a certain percentage. These categories are generally 26% material cost, 45% labor, 22% R.O.W and 7% percent various costs, respectively. Measurement, engineering, inspection, contingent situations, allowances, overheads and filing fees are part of the various costs (Parker, 2004).

A detailed representation of the above-mentioned projects is given in Table 3.4. The equations used to calculate the cost of the four categories determined are as follows:

Material= [(26%*EC)/Length]/Diameters

Labor = [(45%*EC)/Length]/Diameters

R.O.W = [(22%*EC)/Length]/Diameters

Misc. = [(7%*EC)/Length]/Diameters

The meanings of the symbols that are not explicitly stated in the formulas above, respectively, EC is the Estimate of the Cost of Investment and R.O.W is Right Of Way.

Table 3.4: The Cost of TAPI, IP and TANAP

Name	Type	Length(km)	Diameter(inch)	Estimate Cost	Material 26%	Labor 45%	R.O.W 22%	Misc. 7%
TAPI	Onshore	1735	56	$10,000,000,000	$26,759.98	$46,315.36	$22,643.06	$7,204.61
IP	Onshore	2775	56	$7,500,000,000	$12,548.26	$21,718.15	$10,617.76	$3,378.38
TANAP	Onshore	1841	56	$11,000,000,000	$27,741.13	$48,013.50	$23,473.27	$7,468.77
		Av. Onshore pipline cost(-55% offshore)			$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 noted that this equation is provided to calculate the fifty-five percent of offshore pipeline cost base for calculating terrestrial pipeline cost.

It seems that the pipeline development cost shows that the rates of R.O.W also, Misc. are adaptable so it is accepted that the commitment of these two factors in this examination is 29% of the absolute expenses

3.2.5 The Operating Cost

When the production starts, all the costs of consumers, personnel and contractors to be served will be called Operation Cost. The Operating Cost in this research has been assumed annually five percent of the capital cost. (Nederlof, 2010).

Chapter 4

THE PIPELINE ROUTES

4.1 The Pipeline Route for Turkey

4.1.1 The Course of Construction for Turkey

In this context, it was assumed that the pipeline construction process was 3 years. This expectation is taken from the US Energy Information Administration site (EIA, 2008). It has been compared to other projects at different distances, on land and at sea. For example, the 296 km long pipeline construction between Greece and Turkey, it takes about two years until July 2005 to September 2007 (Watkins, 2007).

As stated, the estimated construction period of this project is 3 years. One of the biggest reasons is the closest distance of 295 kilometers occurs between Cyprus and Turkey. Moreover, the path of the pipeline in Turkey if it reaches to Ankara, until the period of construction is extended. This is because of additional 553 onshore pipeline needed to be constructed from the Southern coast to Ankara. The idea is to connect the new Cyprus pipeline into TANAP transmission network or to the existing BOTAS pipeline. At the same time, this 553-kilometer pipeline estimate is another factor that prolongs construction time.

We can assume that the new Cyprus pipeline will consist of 4 stages. These stages are shown in figure 4.1 starting from the source to Ankara. This pipeline is being drawn map of the closest points between Turkey and Cyprus has been selected. Mersin-Anamur has been chosen as the closest location to Cyprus.

Figure 4.1:The route of pipeline between Cyprus and Turkey

The Pipeline route consists of:

First step ~ The distance between the production station between Larnaca and Limassol in the south of Cyprus and the well on the sea floor is 130 kilometers. As a result, a 130 km submarine pipeline will be needed.

Second ~ 75 kilometers of onshore pipeline to be built between Vasilikos and Kyrenia.

Third ~ Kyrenia to Mersin, which is roughly 90 km offshore pipeline from the nearest destination of Turkey.

Fourth ~ 553 km of onshore pipeline to be built between Mersin and Ankara. Ankara is the most convenient natural gas port for TANAP connection.

As a result, the nearly 847-kilometer natural gas pipeline that extends between Cyprus and Turkey was obtained. It has been shown that this line will be 220 kilometers underwater, 627 kilometers on land.

Table 4.1: Pipeline Sections between Cyprus and Ankara

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

Source: Authors own computations.

4.1.2 The Manufacturing Cost – Turkey

According to a part of the construction cost, calculation of construction projects, production cost and estimated cost will be made in the Middle East and Asia. After this process, the cost of the selected projects divided into Materials, Workmanship, R.O.W and Miscellaneous categories. The diameter and length of the pipeline are two most important factors for this method. The purpose of the method is to determine the cost per category.

In line with the results of the studies carried out by SARI, the cost of the coastal construction is approximately 55% of the cost of the submarine pipeline (SARI/EI, 2008). The method used is shown below:

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 meanings of the symbols used in the above formula are as follows; M: Material, Dia: Diameter, Len: Length, L: Labor, R.O.W: Right of Way and Misc.: Miscellaneous.

Table 4.2: Pipeline Construction Costs for Turkey

Welhead to Mersin									
From	To	Type	Appr(km)	Diameter(inc)	Material	Labor	Misc.	R.O.W	C.C
Welhead	Vassilikos	Offshore	130	28	$274,240,902.3	$474,647,715.5	$73,834,089.07	$232,049,994.2	$1,054,772,701.0
Vassilikos	Kyrenia	Onshore	75	40	$124,312,500	$215,156,250	$33,468,750	$105,187,500	$478,125,000
Kyrenia	Mersin	Offshore	90	24	$162,736,359.6	$281,659,083.8	$43,813,635.26	$137,699,996.5	$625,909,075.2
					$561,289,761.9	$971,463,049.3	$151,116,474.3	$474,937,490.7	$2,158,806,776
				Invesment Cost Welhead to Mersin = $2,158,806,776					
Mersin to Ankara									
Mersin	Ankara	Onshore	553	40	$916,597,500	$1,586,418,750	$246,776,250	$775,582,500	$3,525,375,000
				Total Invesment Cost Welhead to Ankara= $5,684,181,776					

Source: Authors own computations.

Entire pipeline construction cost for ~848 km offshore and onshore pipelines between Cyprus and Turkey is almost $5,684,181,776. In more detail;

I) The cost of 130 km Offshore pipeline between Wellhead and Vassilikos is approximately $1,024,772,701

II) The cost of 75 km Onshore pipeline between Vassilikos to Kyrenia is around $478,125,000

III) The cost of the 90 km submarine pipeline from Kyrenia to Mersin is approximately $ 625.909.075.2

IV) The cost of 553 km Onshore pipeline between Mersin and Ankara is approximately $3,525,375,000

The total construction cost of the 295 km pipeline between Wellhead and Mersin is about $ 2,158,806,776 and also about $ 3,525,375,000 for 553 kilometers from Mersin to Ankara. One of the most important elements that should not be overlooked is that the cost of offshore construction is approximately two times higher than the cost of terrestrial pipeline. Even if the distance almost doubled, the result did not change significantly.

4.1.3 The Operating Cost- Turkey

Operating cost is calculated in this section. The operating cost is assumed to be 5% of the manufacturing cost as shown in the Operating Cost Section. Operating cost calculations are shown in the table below. It is also shown as a formula.

$$\textbf{The Annual OPC} = \textbf{Investment Cost} * 5\%$$

Table 4.3: Operational Costs for Turkey

Wellhead to Mersin(Turkey)			Welhead to Ankara	
Investment Cost	$2,158,806,776		Investment Cost	5,648,181,776
Operating cost annually percent	5%		Operating Cost annually percent	5%
The operation cost per year	$107,940,338		The operation cos per year	$282,409,088

Source: Authors own computations.

As a result of the assumptions and calculations in this study, the annual maintenance and operation cost of the 848 kilometers submarine and land pipeline consists of the Wellhead-Mersin route with $ 107,940,338 and the Mersin-Ankara line with the operating cost of $ 282,409,088.

4.2 The Pipeline Route of Europe

4.2.1 The Course of Construction for Europe

In this context, it was assumed that the pipeline construction process was 6 years and the construction was completed and natural gas export started in 2025.

This number has been compared to other projects with different distances, such as Nord Stream. In more details, Nord Stream is approximately 1,224 km and the length of the most suitable route for the export of gas in Cyprus to Europe is calculated as 1,368 km. The construction of Nord stream started in 2006 and was completed at the end of six years. These numbers show us the time required for the year of construction.

The route of the pipeline is intended to be depicted in its closest form in the figure below.

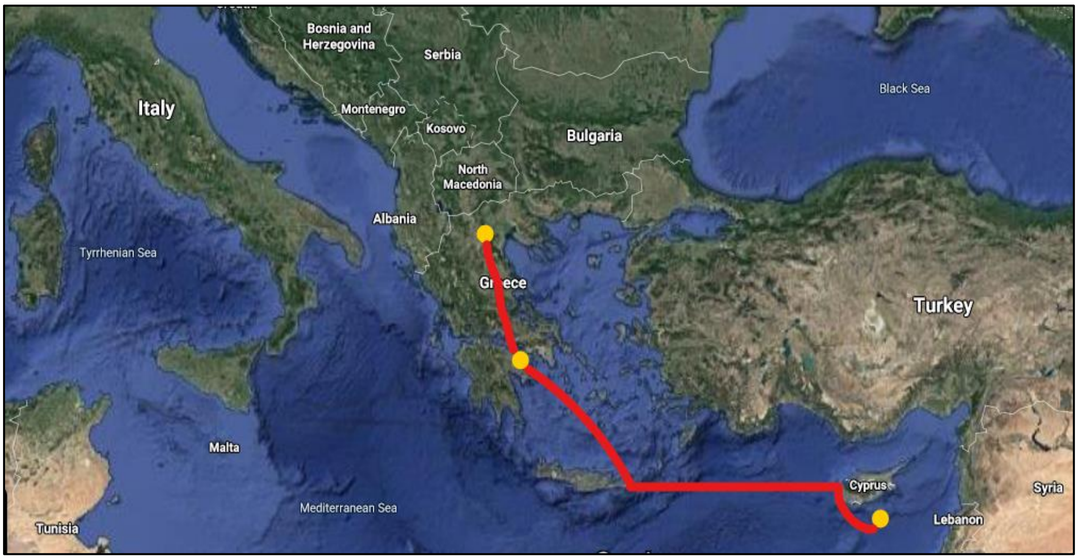

Figure 4.2: The route of pipeline between Cyprus and Europe

The way to take this gas from Cyprus to Europe is as follows;

First step ~ The distance between the production station between Larnaca and Limassol in the south of Cyprus and the well on the sea floor is 130 kilometers. As a result, a 130 km submarine pipeline will be needed.

Second step ~ the 633 km submarine pipeline, starting from Vassilikos and extending to Crete.

Third step - the 405 km submarine pipeline between Crete and the nearest coast (Peloponnese) of Greece.

Fourth step - In order to access the pipeline network (TAP), the distance to be passed on land is approximately 200 kilometers.

Table 4.4: Pipeline Sections from Cyprus to Europe (Crete-Greece)

From	To	Approximately (km)	Pipeline Type	Depth (m)	Diameter inches
Wellhead	Vassilikos	130	offshore	1700	28
Vassilikos	Crete	633	offshore	2000	28
Crete	Greece	405	offshore	1200	24
Greece	TAP	200	onshore	-	40

Source: Authors own computations.

As a result, the line between Cyprus and Europe consists of approximately 1168 km of submarines and 200 km of onshore pipelines.

4.2.2 The Manufacturing Cost of Europe

In this section, the calculation of costs required for transporting gas from Cyprus to Europe will be carried out in the light of the methods shown in section 4.1.2. The formula used to calculate the construction cost is shown below:

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 meanings of the symbols used in the above formula are as follows;

M: Material, Dia: Diameter, Len: Length, L: Labor, R.O.W: Right of Way and Misc.: Miscellaneous.

Table 4.5: The Pipeline Construction Cost for Europe

Welhead to Greece									
From	To	Type	Appr(km)	Diameter(inc)	Material	Labor	Misc.	R.O.W	C.C
Welhead	Vassilikos	Offshore	130	28	$274,240,902.3	$474,647,715.5	$73,834,089.07	$232,049,994.2	$1,054,772,701.0
Vassilikos	Crete	Offshore	633	28	$1,335,342,239	$2,311,169,260	$359,515,218.2	$1,129,904,972	$5,135,931,689
Crete	Greece	Offshore	405	24	$732,313,618	$1,267,465,877	$197,161,358.7	$619,649,984.4	$2,816,590,838
					$2,341,896,759	$4,053,282,853	$630,510,666	$1,981,604,951	$9,007,295,228
				Investment Cost Welhead to Greece=$9,007,295,228					
Greece to Europe									
Greece	TAP	Onshore	200	40	$331,500,000	$573,750,000	$89,250,000	$280,500,000	$1,275,000,000
				Total Invesment Cost Welhead to Europe=$10,282,295,230					

Source: Authors own computations.

The distance between Cyprus and Europe (Crete-Greece) is approximately 1368 kilometers. The total cost of the project with this distance is $ 10,282,295,230. In more detail;

I) The cost of 130 km offshore pipeline between Wellhead and Vassilikos is about $1,054,772,701

II) The cost of 633 km of offshore pipeline between Vassilikos to Crete is about $5,135,931,689

III) The cost of 405 km of offshore pipeline between Crete to Greece is about $2,816,590,838

IV) The cost of 200 km of onshore pipeline between Greece and TAP connection is about $1,275,000,000

The total construction cost of the 1168 km pipeline between Wellhead and Greece is about $9,007,295,228 and also about $ 1,275,000,000 for 200 kilometers from Greece to TAP. As a footnote; Offshore pipeline construction cost is approximately twice the cost of terrestrial pipeline.

4.2.3 The Operating Cost For Europe (Crete-Greece)

Operating cost is calculated in this section. The operating cost is assumed to be 5% of the manufacturing cost as shown in the Operating Cost Section. Operating cost calculations are shown in the table below. It is also shown as a formula.

The Annual OPC = Investment Cost * 5%

Table 4.6: Operational Cost for Europe:

Wellhead to Greece			Welhead to Europe	
Investment Cost	$9,007,295,228		Investment Cost	10,282,295,230
Operating cost annually percent	5%		Operating Cost annually percent	5%
The operation cost per year	$450364761.4		The operation cos per year	$514,114,761.5

Source: Authors own computations.

In this study, the one-year upkeep and operation cost of the 848 kilometers offshore and onshore pipeline routes based on assumptions consists of the Wellhead-Greece route with $107,940,338 and Wellhead-Europe line with operating cost of $282,409,08

Chapter 5

CONCLUSION

The aim of this study is to find out the most viable project to be followed to monetize Cyprus' natural gas reserves. I believe that this study will provide some financial evidences to private investors regarding the financial feasibilities of different options before undertaken a serious investment decision. To achieve this goal, two dominant export options of the natural gas industry were analyzed and calculated using the necessary data.

The results based on the current data and assumptions in this study revealed that the best option for monetizing Cyprus' natural gas reserves is to make it through the natural gas pipeline. Calculations were made primarily by focusing on the LNG option, but the cost of constructing a single terrain LNG plant was found to be expensive for the island. The pipeline option is found to be financially more viable than expected in terms of cost. In particular, such calculations are made for Turkey. The result presented in this project is that, the best scenario is to lay a natural gas pipeline to Turkey. The two most important reasons for this are;

* the proximity of distance between Turkey and Cyprus

* multiple gas pipeline connections in Turkey

Besides that, the result obtained in this study does not include possible natural gas reserves yet to be found in the near future.

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APPENDIX

In 2003, Nathan Parker, a member of the Institute of Transportation Research, presented a paper. This paper showed a way to estimate the cost of NG pipeline construction. Nathan collected the construction cost to create an effective equation to estimate the cost of pipeline projects that used the construction cost of the 893 projects in the United States during the thirteen years. Later, divided into 4 groups: Material cost, Labor cost, Miscellaneous costs and Right Of Way cost. These parameters were used in Regression studies and a linear equation was obtained which is a Length and Pipeline Diameter based equation.

Appendix Table 1

Material Cost (dia, length) =[330.5(dia)^2+687(dia)+26,960] (length)+35,000
Labor Cost (dia, length) =[343(dia)^2+2,047(dia)+170,013] (length)+185,000
Misc.Cost(dia, length) =[8,417(dia)+7,234] (length)+95,000
R.O.W(dia,length)=[577(dia)^2+29,788](length)+40,000

*Dia is in inches *Length is in miles *Cost is in dollars

It ought to be referenced that the length in this equation depends on inch so the length will be changed over from km to inch and furthermore 1 km is equivalent the almost 0.6 miles. It should be noted that the formula is taken from the data between 1991 and 2003, so the outcome should be refurbished. So as to ascertain the expense of the task in 2019, the worldwide swelling paces of 2004 - 2019 were gathered and the normal for refreshing the yield of the equation was taken. The worldwide swelling rates during the 16 years and 4.40% are the normal will be utilized in the figuring.

NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Inflation	3.38%	4.10%	4.26%	4.80%	8.95%	2.92%	3.34%	4.83%	3.73%	2.59%	2.29%	1.45%	1.47%	2.18%	2.45%	2.00%

Average of Inf.	3.42%

Appendix 1: Turkey

Welhead to Mersin									
From	To	Type	Appr(km)	Diameter(inc)	Material	Labor	Misc.	R.O.W	C.C
Welhead	Vassilikos	Offshore	130	28	$44,885,815.92	$73,300,350.08	$35,847,487.3	$70,857,910.78	$224,891,564.09
Vassilikos	Kyrenia	Onshore	75	40	$27,204,565.22	$37,534,673.91	$16,120,031.06	$44,433,850.93	$125,293,121.12
Kyrenia	Mersin	Offshore	90	24	$23,828,108.41	$42,755,482.78	$21,448,706.95	$36,879,728.97	$124,912,027.1
					$95,918,489.55	$153,590,506.78	$73,416,225.3	$152,171,490.68	$475,096,712.31

Upgrate the Result								
2003	2004	2005	2006	2007	2008	2009	2010	2011
$475,096,712.31	$507,593,327	$524,953,019.2	$542,906,412.	$561,473,811.8	$580,676216.2	$600,535,342.8	$621,073,651.5	$642,314,370.4
2012	2013	2014	2015	2016	2017	2018	2019	
$664,281521.9	$686,999,949.9	$710,495,348.2	$734,794,289.	$759,924,253.8	$785,913,663.3	$812,791,910.6	$840,589,393.9	

Total Investment cost from Wellhead to Mersin: $840,589,393.9

Mersin to Ankara									
From	To	Appr.(km)	Appr.(mil)	Diameter(inch	Material	Labor	Misc	R.O.W	C.C
Mersin	Ankara	553	343,47	40	$200,365,260.8	$275,576,595.65	$118,252,895.65	$315,370,660.87	921,565,413.04

Upgrate the Result								
2003	2004	2005	2006	2007	2008	2009	2010	2011
921,565,413.04	$975,600,487.3	$1,008,966,024	$1,043,472,66	$1,079,159,427	$1,116,066,679	$1,154,236,159	$1,193,711,036	$1,234,535,953
2012	2013	2014	2015	2016	2017	2018	2019	
$1,276,757,083	$1,320,422,175	$1,365,580,613	$1,412,283,47	$1,460,583,565	$1,510,535,523	$1,562,195,838	$1,615,622,936	

Total Investment cost from Wellhead to Ankara: 2,456,212,330

Appendix II: Europe

Welhead to Greece									
From	To	Type	Appr(km)	Appr(mil)	Material	Labor	Misc.	R.O.W	C.C
Welhead	Vassilikos	Offshore	130	80.74534161	$44,885,815.92	$73,300,350.08	$35,847,487.3	$70,857,910.78	$224,891,564.09
Vassilikos	Crete	Offshore	633	393	$218,220,080	$354,923,114.5	$173,807,727.7	$344,595,105.5	$1,091,545,573
Crete	Greece	Offshore	405	251	$106,768,756.4	$190,507,198.2	$95,704,240	$165,340,254.5	$558,320,449.1
					$369,874652	$618,730,662.5	$305,359,455	$580,793,270.8	$1,874,757,586

Upgrate the Result								
2003	2004	2005	2006	2007	2008	2009	2010	2011
$1,874,757,586	$2,002,991,005	$2,071,493,297	$2142338368	$2,215,606,340	$2,291,380,077	$2,369,745,276	$2,450,790,564	$2,534,607,601
2012	2013	2014	2015	2016	2017	2018	2019	
$2,621,291,181	$2,270,939,339	$2,803,653,464	$2,899,538,41	$2,998,702,626	$3,101,258,256	$3,207,321,288	$3,317,011,676	

Investment Cost Welhead to Greece=$3,317,011,676

Greece to Europe(TAP)										
Greece	TAP	Onshore	200	40	124	$72,356,760	$99,470,932	$42,751,496	$42,751,496	$118,210,512

Upgrate the Result								
2003	2004	2005	2006	2007	2008	2009	2010	2011
$118,210,512	$126,296,111	$130,615,438	$135,082,486	$139,702,307	$144,480,125.9	$149,421,346.2	$154,531,556.2	$159,816,535.4
2012	2013	2014	2015	2016	2017	2018	2019	
$165,282,260.9	$170,934,914.2	$176,780,888.3	$182,826,794.1	$189,079,471.1	$195,545,989	$202,233,661.8	$209,150,053	

Total Invesment Cost Welhead to Europe=$3,526,161,729