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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 transport it. The aim of this paper is to estimate whether it is financially feasible to transport the natural gas found in Cyprus to one closest potential market, namely, Turkey. To attain a conclusion, the transportation price of natural gas through a gas pipeline to Turkey 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 transport the natural gas found in Cyprus to Turkey. Also various sensitivity analyses in this paper showed that the possible profit of Turkey 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.

1. Introduction

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 [1,2]. Certainly, the spread of Gas transportation conducts the globe to sustainable transportation, which is of interest in many areas of research in different industries [3-14], process control [35] and the resistance of infrastructures [15-16]. 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 [17]. 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 [18]. 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. 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.

2. Methodology

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 to 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 [19].

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 1) [20]. This potential has resulted in its faster and more tangible growth of economy in the world.

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 [21, 22].

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 [23, 24] assumed the shore of Turkey is located in Mersin between Bozyazi and Anamur in Turkey. Figure 2 shows the locations.

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.

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

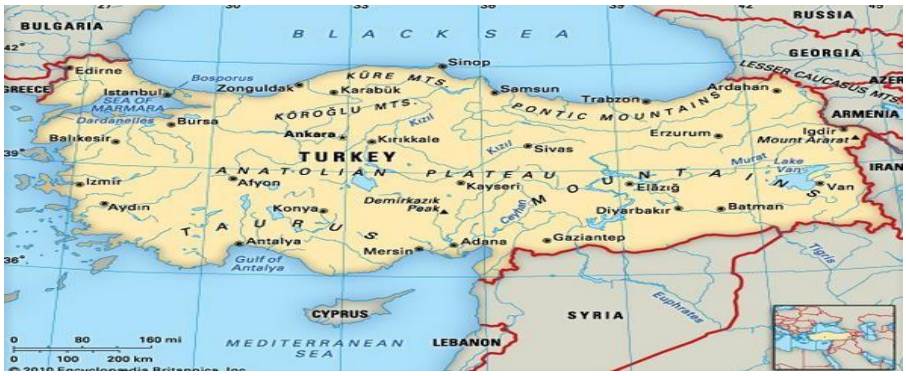

Figure 1. Overview of Turkey and the Neighboring Countries

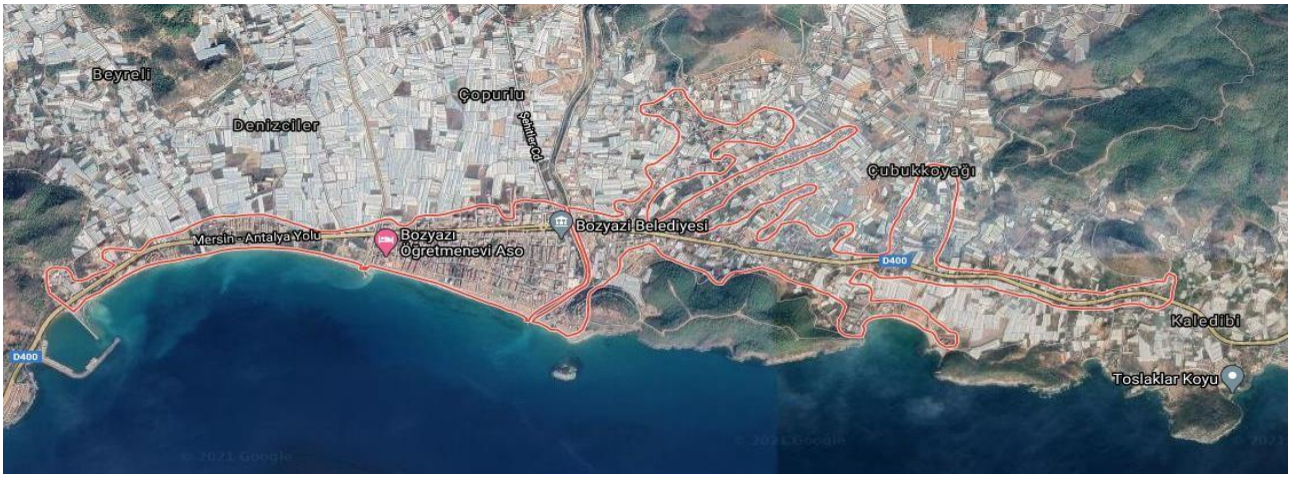

Figure 2. An Overview of Anamur and Bozyazi in Mersin, Turkey (Google Map)

Table 1. The Pipeline Segments from Wellhead in Cyprus to Ankara

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

3. Result and Discussion

The main purpose is to determine the cost and transportation price of natural gas per 1000 cubic meters, which will be transported from Cyprus to Turkey via pipeline unless the transportation 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.

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 (Table 2).

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 [25,26]. 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.) (1)

Offshore pipeline Cost Construction = [(M×Dia.×Len.) + (L×Dia.×Len.) + (R.O.W×Dia.×Len.) + (Misc.×Dia.×Len.)]/55% (2)

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.

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 (Table 3). In this study, the operating cost is assumed 5% of manufacturing cost which is generally described. The operating cost calculation and formula are as follows:

The Annual OPC = Investment Cost * 5% (3)

Table 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	Vasilikos	Offshore	130	28	$147.914.997	$256.006.725	$39.823.268	$125.158.843	$568.903.835
Vasilikos	Kyrenia	Onshore	75	40	$67.049.380	$116.047.004	$18.051.756	$56.734.091	$257.882.232
Kyrenia	Mersin	offshore	90	24	$87.773.734	$151.916.079	$23.631.390	$74.270.083	$337.591.286
Total investment cost from Wellhead to Mersin					$302.738.112	$523.969.809	$81.506.414	$256.163.018	$1.164.337.354
Mersin	Ankara	Onshore	553	40	$494.337.432	$855.653.248	$133.101.616	$418.319.366	$1.901.451.664
Total investment cost from Wellhead to Ankara									$3.065.829.018

Table 3. The Operating Cost Calculation for Turkey

Parameters	Wellhead to Mersin (Turkey)	Wellhead to Ankara (Turkey)
Investment cost	$1.164.337.354	$3.065.829.018
Operating cost annually percent	5%	5%
The operating cost per year	$58.218.867	$153.291.450

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. In order to determine the amount of gas that will be transported to Turkey, it is required to specify the domestic consumption in Cyprus.

According to U.A Energy Information Administration, the amount of oil imports by South Cyprus was around 60,000 barrels per day at 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 oilconsumption in this country can be estimated. Therefore, inorder 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 [27-28]. 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 Mcm 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 transported to whole Cyprus. The formula is as follows (Eq. (4))

1 Oil bbl. = ~0.17 Mcm (4)

The initial capability of natural gas transporting by pipeline is assumed around 11,898.017 thousand cubic meters (Mcm) per day [29][34].

According to table 4, The remaining of gas production can be transported to Turkey, which is around 8498.58 thousand cubic meters per day. The Natural Gas that will be transported 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 transported during the life of project to Turkey is around 21,127,177 Mcm.

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, the required calculation is done as follows (Table 5):

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.

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 Transportation 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 Transportation) + (AOP/AE) + GPW (5)

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

In order to determine the transportation 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 Gaswhich 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 6.

Table 4. The PV of Natural Gas That Will Be Transported to Turkey from Cyprus

Title	1000 cubic meters
Transport Volume/Daily	8.498
Transport Volume/Annual	3.101.981
Discount Rate	12%
Life of Project	15 years
PV	21.127.177

Table 5. The Cost and Transportation Price of Gas per Mcm for Turkey

Wellhead to Mersin (Turkey)					
Title 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	-	21.127.177	$55.1	$73.88
Operating cost/year	$58.218.867	3.101.981	-	$18.77	
Gas Price at Wellhead				$121.62	
Transportation Price to Mersin				$195.50	
Wellhead to Ankara (Turkey)					
Investment Cost	$3.065.829.018	-	21.127.177	$145.11	$194.53
Operating cost/year	$153.291.450	3.101.981	-	$49.42	
Gas Price at Wellhead				$121.62	
Transportation Price to Ankara				$316.15	

Table 6. The Weighted Average of Import Gas Price to Turkey

Name of Countries	Percentage/Total Gas	Price/Mcm	Weighted average
Russia	58%	$418	$242.22
Iran	19%	$487	$29.53
Azerbaijan	13%	$340	$44.20
Total	90%	$1245	$379.17
Weighted average of imported price			$421.30

The formula is as follows:

$$[(WR^* PR) + (WI^* PI) + (WA^* PA)]/ (WR+ WI+WA) \quad (6)$$

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

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.

The wellhead price is used to determine the transportation 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 7. The scope of investigation is ±30% variation in wellhead price.

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.

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 8. 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.

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.

Table 7. The Sensitivity Analysis of Wellhead Price for Turkey

Percentage Change	Price at Wellhead/MMBtu	Price at Wellhead/Mcm	Transportation Price/Mcm	Saving in Turkey/Mcm	Saving In Turkey/year
-30%	$2.35	$85.12	$279.66	$141.64	$439.360.021
-205%	$2.68	$97.29	$291.82	$129.48	$401.634.963
-10%	$3.02	$109.45	$303.98	$117.32	$363.909.905
0%	$3.35	$121.62	$316.15	$105.15	$326.184.848
10%	$3.69	$133.62	$328.31	$92.99	$288.459.790
20%	$4.02	$145.98	$340.47	$80.83	$250.734.732
30%	$4.36	$158.10	$352.63	$68.67	$213.009.675

Table 8. The Sensitivity Analysis of Import Price in Turkey

Percentage Change	Average of important price in Turkey	Saving in Turkey/Mcm	Transportation Price/Mcm
-30%	$292.91	$21.24	$65.874.618
-205%	$337.04	$20.89	$64.811.870
-10%	$379.17	$63.02	$195.498.359
0%	$421.30	$105.15	$326.184.848
10%	$463.43	$147.28	$456.871.337
20%	$505.56	$189.41	$587.557.826
30%	$547.69	$231.54	$718.22.315

4. Conclusions

As regards to the transportation price that is computed based on the assumption in this study and average import price in Turkey, it can be stated the transport natural gas from Cyprus to Turkey is possible. The results based on existing data and assumptions in this study show the Transportation Natural gas from Cyprus to Turkey 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 transportation 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. For more clarification, some new methods can be applied in the future [30-33].

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