AMERICAN UNIVERSITY OF BEIRUT

PIPELINES, PIPE PLANS, AND PIPE DREAMS: AN ECONOMIC AND GEOPOLITICAL PERSPECTIVE ON BUILDING NATURAL GAS EXPORT INFRASTRUCTURE FROM LEBANON AND THE EAST MEDITERRANEAN

by
REEM MAAROUF SALAMEH

A thesis
submitted in partial fulfillment of the requirements
for the degree of Master of Science
to the Department of Mechanical Engineering
of the Maroun Semaan Faculty of Engineering and Architecture
at the American University of Beirut

Beirut, Lebanon
June 2019

AMERICAN UNIVERSITY OF BEIRUT

THESIS/DISSERTATION FULL TITLE

by
STUDENT FULL NAME

Approved by:

RIAD CHEDID, Professor, ECE [Signature]
[Dr. Full Name, rank] Advisor
[Department]
(as listed in AUB Catalogue of current year)

LEILA DAGHER, Associate Prof, Economics [Signature]
[Idem] Member of Committee

Nesreen Ghaddar, Professor, ME [Signature]
[Idem] Member of Committee

Karim Makdisi, Associate Professor, PSPA [Signature]
[Idem] Member of Committee

Date of thesis/dissertation defense: [Month Day, Year]

AMERICAN UNIVERSITY OF BEIRUT

THESIS, DISSERTATION, PROJECT RELEASE FORM

Student Name:
____Salameh______________________Reem_____________Maarouf
Last First Middle

☑ Master's Thesis ◯ Master's Project ◯ Doctoral Dissertation

☐ I authorize the American University of Beirut to: (a) reproduce hard or electronic copies of my thesis, dissertation, or project; (b) include such copies in the archives and digital repositories of the University; and (c) make freely available such copies to third parties for research or educational purposes.

☑ I authorize the American University of Beirut, to: (a) reproduce hard or electronic copies of it; (b) include such copies in the archives and digital repositories of the University; and (c) make freely available such copies to third parties for research or educational purposes
after:

One ---- year from the date of submission of my thesis, dissertation, or project.
Two ---- years from the date of submission of my thesis, dissertation, or project.
Three -✓- years from the date of submission of my thesis, dissertation, or project.

Reem Salameh Aug, 28, 2019

Signature Date

ACKNOWLEDGMENTS

I am grateful for the excellent guidance of my thesis adviser, Professor Riad Chedid, my thesis co-adviser, Professor Leila Dagher, and my committee members, Professor Nesreen Ghaddar, Professor Karim Makdisi.

I am also thankful for Prof. Jamal Saghir, Dr. Chafik Masri, Dr. Hassan Hamiye, Mr. Hassan Hamdan, and Ms. Sahar Fneich for sharing their insightful comments and knowledge related to my thesis topic.

I acknowledge the tremendous support of the MCF family at AUB, friends, and family. Last but not least, I deeply recognize Rama Salameh's encouragement throughout the journey.

AN ABSTRACT OF THE THESIS OF

Reem Maarouf Salameh for Master of Science
Major: Energy Studies

Title: Pipelines, pipe plans, and pipe dreams: An economic and geopolitical perspective on building natural gas export infrastructure projects from Lebanon and the East Mediterranean

Discoveries of natural gas reserves in the East Mediterranean have increased interest in the Levant Basin, and its potential to supply natural gas to regional and European countries. Lebanon is a potential newcomer to the East Mediterranean gas exporting countries, since the projected needs of the country are minimal as compared to the expected reserves. This work sheds light on different export pipelines connecting Lebanon with Turkey, Iraq, Egypt, and Italy. We investigate the economic and political potential of the various proposed pipeline projects under different discovery scenarios, prices of natural gas, and risk rates. Results indicate that the most attractive projects in economic terms are prone to significant political risks. According to the latest developments in the region, Russia's chance of shaping the East Med resources is high. However, the final decision to build or forgo pipeline projects in the region is dependent on market conditions, sovereign decisions, and intervention of political powers affecting the East Mediterranean.

CONTENTS

ACKNOWLEDGEMENTS v

ABSTRACT... vi

LIST OF ILLUSTRATIONS.. x

LIST OF TABLES... xi

Chapter

I. INTRODUCTION.. 1

II. LITERATURE REVIEW.. 5

A. Global Natural Gas Overview.. 5

B. Natural Gas Discoveries in the Levant Basin.............................. 11

C. Prospects of Natural Gas Reserves in Lebanon – Brief history.............. 14

D. Natural Gas Supply, Demand and Pipelines in Lebanon: History and Future Projections.. 16

E. Natural Gas Demand and Supply in Europe and the Middle East.......... 18

F. Major Recent Existing and Planned Pipeline Infrastructure to Deliver Natural Gas from Russia, the Caspian and East Mediterranean Region.. 22

1. The Caspian Region and Russia.. 22

a. Nabucco Pipeline... 22
b. BTE-TANAP-TAP Pipelines................................. 23
c. Turkish Stream... 24
d. South Stream... 24

2. The East Mediterranean Region.. 26

a. “Israel”-Turkey Pipeline..................................... 26

b. Cyprus to Egypt Pipeline……………………………….. 26
c. Arab Gas Pipeline………………………………………. 26
d. Islamic Pipeline……………………………………… 27
e. East Med Pipeline……………………………………. 28
f. Other forms of the East Med Pipeline…………………... 30

III. MAJOR GEOPOLITICAL PLAYERS AFFECTING THE DEVELOPMENT OF NATURAL GAS RESERVES IN THE EAST MEDITERRANEAN……………………………………….. 32

IV. COOPERATION IN THE EAST MEDITERRANEAN BASIN…………………………………………………… 39

V. LEBANON'S IDENTIFIED EXPORT OPTIONS IN PREVIOUS REPORTS…………………………………….. 41

VI. PROPOSED HUBS, MARKETS, AND PIPELINES IN THE EAST MEDITERRANEAN……………………..… 44

A. Italy…………………………………………………………………… 45

B. Turkey………………………………………………………………... 46

C. Iraq……………………………………………………………………….. 47

D. Egypt……………………………………………………………………... 48

E. Suggested Pipelines……………………………………………………. 48

VII. ECONOMIC CALCULATIONS METHOD...………..… 54

A. Costs Calculations…………………….………………………… 55

VIII. ECONOMIC FEASIBILITY RESULTS…...…………… 61

A. Case A: 20 inch- pipeline………...…………………………………… 61

B. Case B: 36 inch- pipeline…………...…………………………………… 63

C. Case C: 48 inch- pipeline…………...…………………………………… 64

XI. DISCUSSION OF DIFFERENT PIPELINES OPTIONS. 66

X. BRIEF OUTLOOK REGARDING THE LNG OPTION.. 71

XI. CONCLUSION AND POLICY IMPLICATIONS……… 72

Appendix

A. UNITS AND CONVERSION FACTORS................................. 74

B. TABLES... 75

BIBLIOGRAPHY.. 88

ILLUSTRATIONS

Figure		Page
1.	Volumes of natural gas (bcm) produced by leading natural gas producers in 2017……………………………………………………….	3
2.	Volumes of total proved reserves (tcm) in different locations in 1997, 2007, and 2017…………………………………………………….....	6
3.	Pipeline gas and LNG traded volumes in 2017………….........................	8
4.	Major pipeline gas and LNG Trade movements in 2017.........................	9
5.	Average price of natural gas ($/mmbtu) for the period 2007-2017……………………………………………..........................	10
6.	Location of the Levant Basin in the Eastern Mediterranean….................	12
7.	Lebanon's offshore blocks…...…………………………………………	16
8.	Global Gas demand by region and sector between 2017 and 2035..........	20
9.	Major new transit pipelines from Russia and the Caspian Region to Europe………………………………………………....................	25
10.	Suggested pipelines trajectories……………………………………......	51

TABLES

Table		Page
2.1.	Major natural gas fields discovered in the Levant Basin…………………………..	13
2.2.	Details of major new transit pipelines from Russia and the Caspian Region to Europe………………………..	24
2.3.	Diameter and length of different sections of the AGP............................	27
6.1.	Suggested pipelines from Lebanon to Turkey, Iraq, Egypt and Italy.....	50
6.2.	Distances based on literature values and point measurements................	50
6.3.	Diameter and capacity of proposed pipelines in 3 different cases..........	54
7.1.	World Bank Natural Gas Price forecast between 2020 and 2030….......	60
8.1.	IRR (%) for suggested 20 inch pipelines under low and high risk scenarios………………………………………………………………..	62
8.2.	IRR (%) for suggested 36 inch pipelines under low and high risks scenarios…………………………………………………....................	63
8.3.	IRR (%) for suggested 48 inch pipelines under low and high risk scenarios………………………………..	65

CHAPTER I

INTRODUCTION

In light of climate change, natural gas is favored among fossil fuels since it emits smaller amounts of CO_2 to produce energy. Therefore, natural gas gained leverage, and is currently perceived as the most favored transit fuel, until renewable energy and storage technology matures. However, in the early days of hydrocarbon exploration and production, natural gas was considered a non-useful product, and was either vented into the atmosphere or burned off at the well. After world war II, construction of natural gas pipelines started, and transportation of natural gas became possible. Accordingly, uses of natural gas were developed for residential applications such as heating homes, and for industrial applications such generating electricity (Natgas, 2013).

Costs of natural gas transportation and storage are relatively high since the energy density[1] of natural gas is low as compared with other fossil fuels. Hence, natural gas is mostly consumed locally via intrastate pipelines, or transported regionally via interstate pipelines (EIA, 2014). The latter, also known as cross country pipelines, traverse the borders of two or more countries, and imply a need for cooperation between concerned states; namely exporting, transit and importing countries. Given the complex framework of cooperation, the flow of gas in interstate pipelines is subject to geopolitics, particularly international relations between concerned countries in a specific geographic zone.

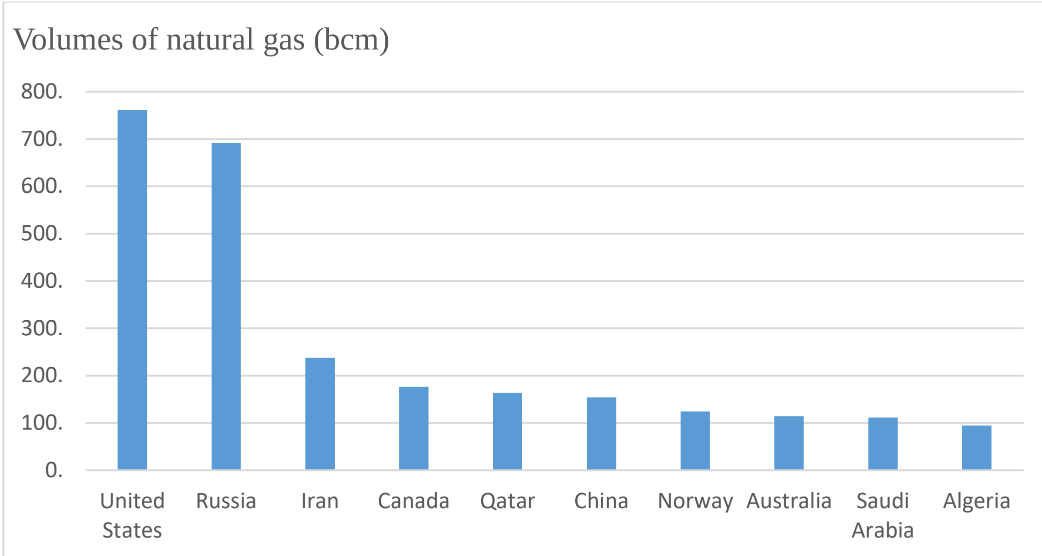
[1] Energy density is the amount of energy stored in a given volume.

Natural gas transportation was first limited to regional markets since it was not feasible to reach remote locations by pipelines, neither technically nor economically. As liquefaction technologies were developed, liquefied natural gas (LNG) could be transported safely across seas and oceans (CLNG, 2019). In simple terms, the process consists of cooling natural gas to reach its liquid form, known as LNG, transporting LNG by ships to consumers, and re-gasifying LNG for consumption in the final market destination (Ferrer & Hamdan, 2016). Although LNG offers flexibility in terms of delivery destination, the cost of liquefying natural gas, shipping the final product as LNG, and re-gasifying it render the process expensive. Not surprisingly, the price of LNG is higher than that of pipeline gas.

Over the past decades, worldwide reserves of natural gas have increased from 128.1 trillion cubic meters (tcm) in 1997 to 193.5 tcm in 2017 (BP, 2018). As new recoverable reserves were discovered, the global production of natural gas has increased from 2.94 tcm in 2007 to 3.68 tcm in 2017 (BP, 2018). In 2017, the major producers of natural gas were the U.S., Russia, Iran, Canada, and Qatar.[2] Graph 1 shows the share of production of each country in 2017 (Statista, 2018).

---

[2] Worthy to note, the yearly share of production of each country is variable based on market conditions, national energy policies, and political standing of the countries.



Graph 1: Volumes of natural gas (bcm) produced by leading natural gas producers in 2017.

In light of new discoveries of natural gas reserves, energy security landscape is rapidly changing. One of the latest discoveries took place in the East Mediterranean, a maritime area known as the Levantine basin, where emerging gas producers are looking to discover around 122 trillion cubic feet (tcf) of natural gas (USGS, 2010). Lebanon, a relatively small country, located on the East Mediterranean, is expected to join the club of emerging gas producers and exporters. Although some of the prospective natural gas is expected to be consumed locally, the remaining volumes are likely to be exported to different markets, via either pipelines or LNG cargos.

In essence, the final decision regarding establishment of natural gas trade pipelines or LNG facilities is made based on economic and political considerations, a process that affects in turn the development of other alternative pipelines (Mitchell, Morita, Selley, & Stern, 2001). This work aims to explore economic viability of different pipeline routes to export Lebanese natural gas to different markets, where each option will be framed within geopolitical considerations. As such, insights regarding Lebanon's export options of pipeline gas will be analyzed to support and inform decision makers about implications of various options for Lebanon.

CHAPTER II

LITERATURE REVIEW

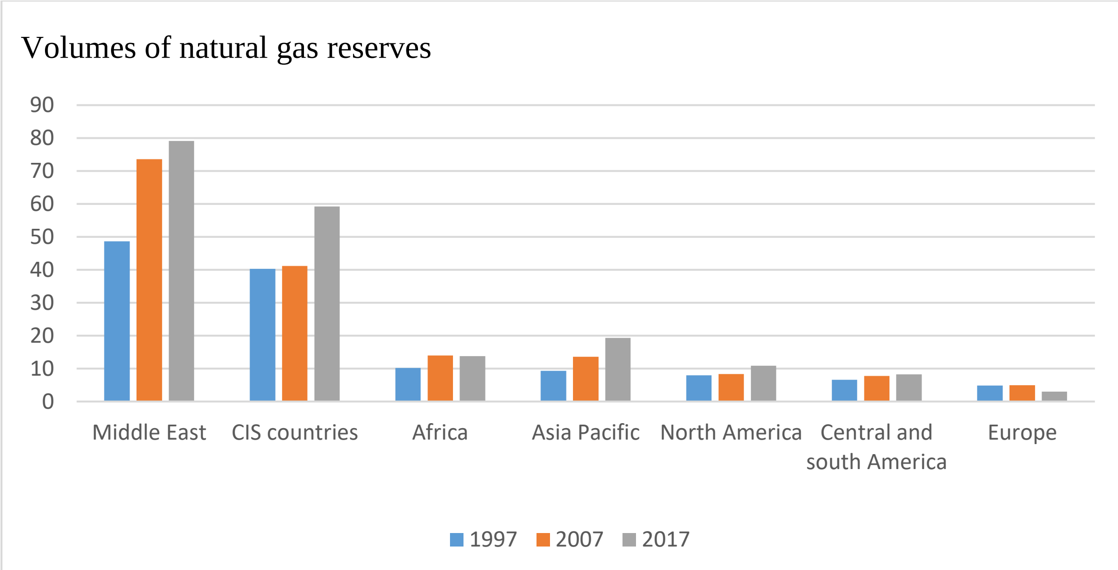
A. Global Natural Gas Overview

According to the latest statistical report published by British Petroleum (BP) in 2018, natural gas reserves are concentrated in the Middle East and the Common Wealth of Independent States (CIS) regions.[3] As shown in graph 2, the total volume of natural gas reserves witnessed an increase in all continents, except Europe, mainly due to development of fossil fuel exploration and production technologies.[4]

To estimate the lifetime of natural gas fields, a widely used Reserves to Production ratio (R/P) is calculated by dividing the total volume of available natural gas in a reserve by the volume produced from the same reserve in a specific year. According to the 2017 dataset, the average worldwide R/P is 52.6 years; however, a large gap is observed between the R/P of each country. While the Middle East and CIS countries' reserves are expected to last, respectively, 119.9 and 72.6 years, Europe and North America's reserves are expected to last, respectively, 12.2 and 11.4 years (BP, 2018). If no major reserves were found, and demand for natural gas either remained stable or increased, supply profile of natural gas could dramatically change in the next decade.

[3] CIS are formerly known as the Soviet Union, and include: Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan.

[4] Fracking technologies and shale gas revolution have contributed to the increase in the total volume of recoverable reserves.



Graph 2: Volumes of total proved reserves (tcm) in different locations in 1997, 2007, and 2017.

To assess supply and demand of natural gas, we refer to the total volumes of import and Export of natural gas. Figure 1 shows major trade movement of pipeline gas and LNG in 2017, and graph 3 shows traded gas volumes per region in 2017 (BP, 2018). Europe, imports 43.1% of the globally traded natural gas, and exports a share of 17% to Ukraine and various European countries. Among European exporters, Norway is leading exports and accounting for a total volume of 109.2 billion cubic meter (bcm) of pipeline gas and 5.8 bcm of LNG.

CIS countries are the major exporters of natural gas as they account for 26.3% of the globally exported natural gas. While some of the produced natural gas is traded internally, 197.7 bcm are exported to Europe via pipelines. Among CIS countries, Russia is the major exporter of natural gas, accounting for a total of 215.4 bcm of exported pipeline gas, and 15.4 bcm of LNG.

In the Middle East, Iran, Qatar, and Oman are the major exporters of natural gas. Iran exports a total of 12.5 bcm of pipeline gas to, mainly, Turkey, and other CIS and Middle Eastern countries. Qatar's relatively modest gas pipeline exports, estimated around 18.4 bcm, are delivered to United Arab Emirates (UAE)[5] and other regional countries. Qatar's large LNG exports, estimated around 103.4 bcm, are sent to Europe and Asia pacific. Oman was also successful in exporting 11.4 bcm of LNG to Asia pacific and other Middle Eastern countries.

Africa accounts for 8.9% of the total exported natural gas. Out of the total 45 bcm of African pipeline gas, 33 bcm were exported from Algeria to Europe. In addition, a significant 55.4 bcm of LNG were exported from Algeria, Nigeria, and some other African countries.[6] While the market for African LNG is diverse, Europe imported around 50% of the total African LNG.

The American continent and Australia are also significant contributors to the international trade of natural gas. However, pipeline gas exports have been challenged by the long geographic distance separating them from Eurasian and African markets. Therefore, exports of pipeline gas remained local. The American continent exported a total

[5] UAE imports 16.4 bcm of pipeline gas from Qatar.

[6] These countries are Angola, Equatorial Guinea, and Egypt.

of 36.6 bcm of LNG to global destinations, while Australia exported 75.9 bcm of LNG, mainly to Asia Pacific.

Last but not least, Asia Pacific, also considered a booming LNG market, exported around 79.1 bcm of LNG, mostly designated for trade within Asian Pacific countries.

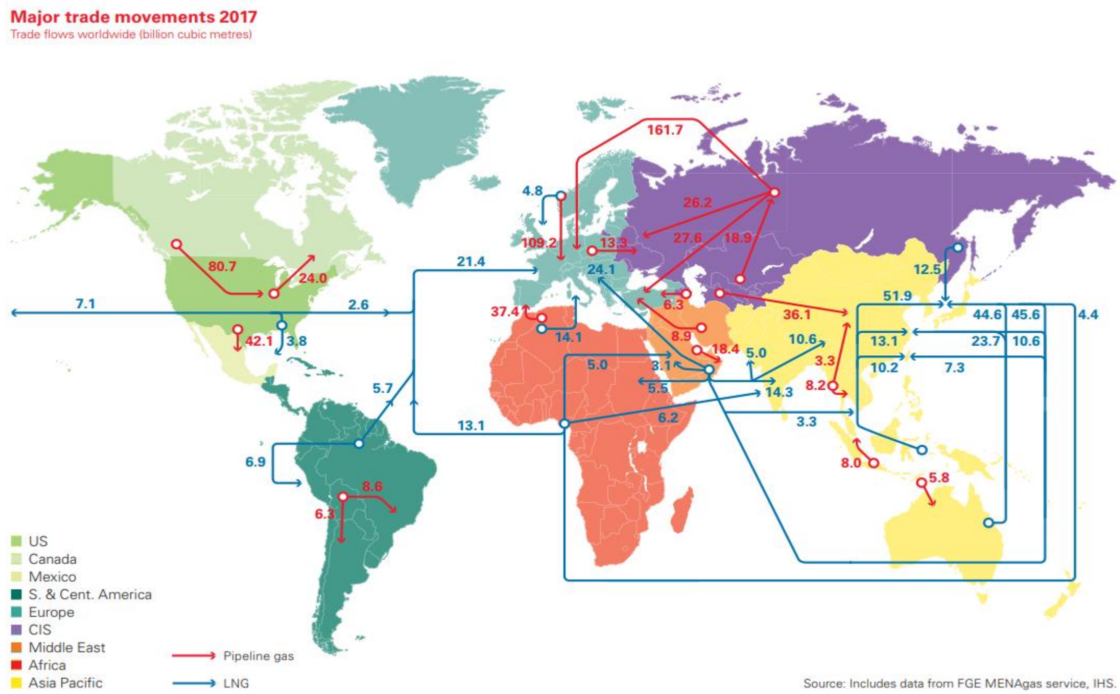
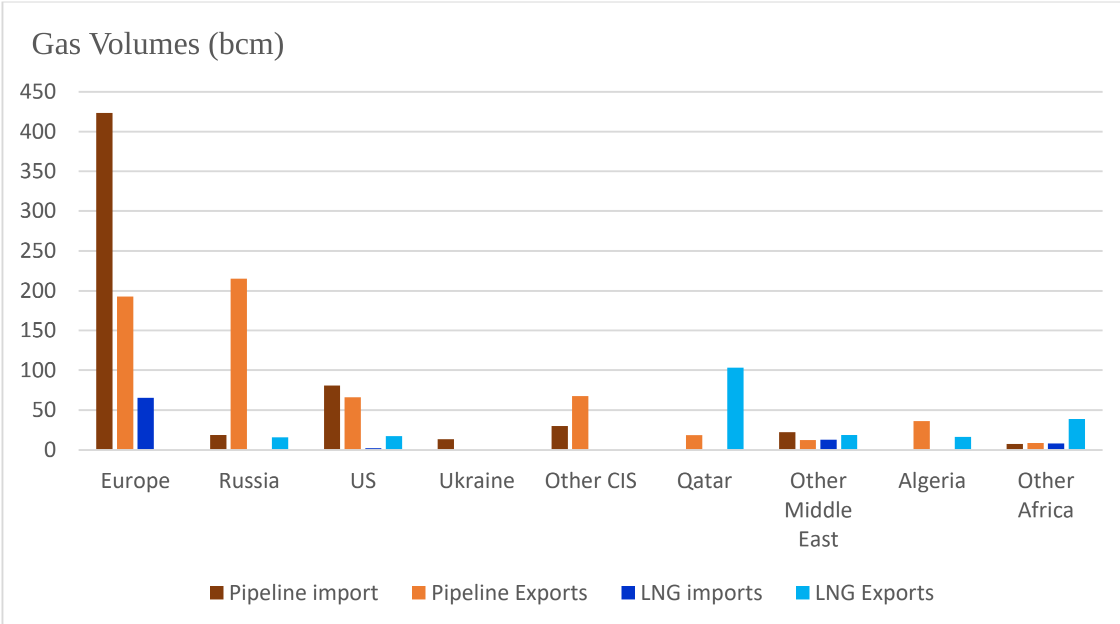


Figure 1 Major pipeline gas and LNG Trade movements in 2017.



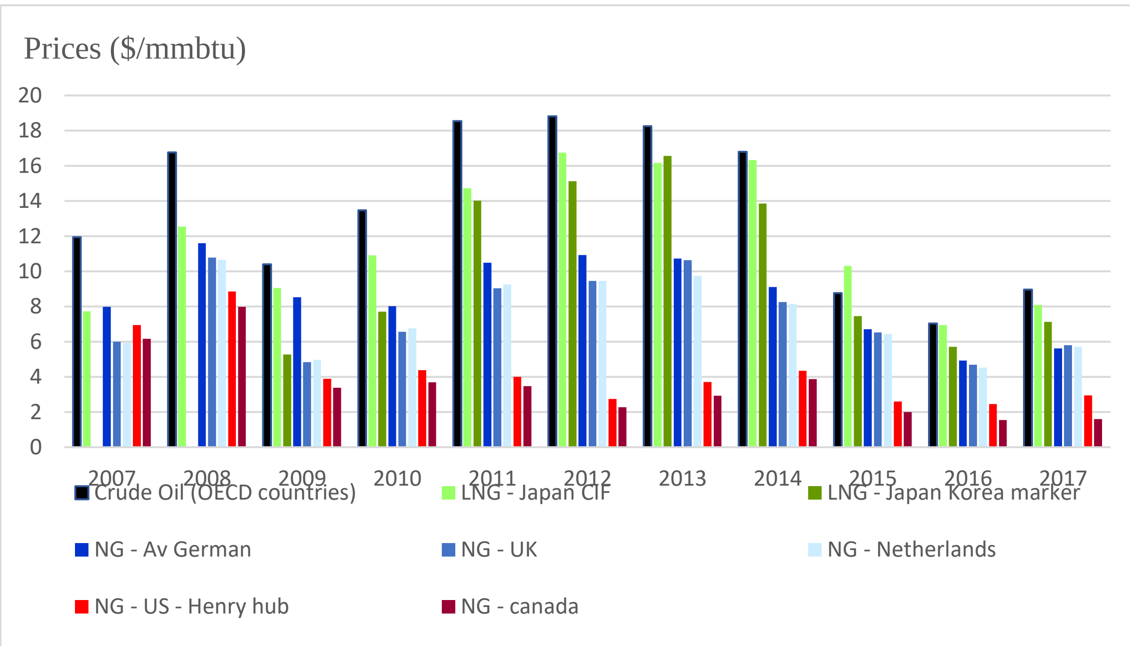
Graph 3: Pipeline gas and LNG traded volumes in 2017.

Three global markets for natural gas are identified: The Asian, European, and American markets. The Asian markets abide by an oil linked indexation system, where the price of natural gas follows the price of crude oil. However, American markets, with a clear dominance of a capital system, follow a hub indexation mechanism where the price of natural gas is determined according to supply and demand of the commodity, or what is referred to as gas on gas competition. Advocates of hub pricing argue that the mechanism is immune to oil market volatility. The main difference between the two systems is that the oil linked markets determine the price based on a preferential treatment towards the producer, while the hub indexation encourages competition (Zhang, Wang, Shi, & Liu, 2018). Europe is shifting from oil indexation to hub pricing mechanism (Shi, 2016).

Prices of natural gas vary across different markets. The average price of natural gas in America, Europe, and Asia was calculated on a yearly basis between 2007 and 2017;

results are presented in graph 4 (BP, 2018). Unsurprisingly, the price of LNG is higher than the price of pipeline gas since LNG requires additional processing to liquefy natural gas, and then re-gasify it before final consumption.

Global price of pipeline gas was comparable between different markets in 2007 and 2008. However, a significant gap between the European and American price is witnessed between 2009 and 2017, where the average European price for the suggested period (7.6 $/mmbtu) is 2.5 times higher than the American price (3.1 $/mmbtu).



Graph 4: Average price of natural gas ($/mmbtu) for the period 2007-2017.

B. Natural Gas Discoveries in the Levant Basin

The Levant basin, shown in figure 2, is located in the East Mediterranean, and encompasses an area of around 83,000 km^2. The basin is limited by the Levant Transfrom zone to the east, the Tartus Fault to the north, the Eratosthenes Seamount to the northwest, the Nile Delta Cone to the west and southwest, and the compressional structures in Sinai to the south (USGS, 2010).

Based on published commercial data and geologic information from gas wells, the U.S. Geological Survey assessed the potential for undiscovered gas, back in 2010. The study focused on estimating the undiscovered technically recoverable gas, and disregarded the economic aspect of the process. Results revealed the presence of 50 to 227 trillion cubic feet (tcf) of undiscovered gas in the Levant basin, with a mean volume of 122 tcf (USGS, 2010).

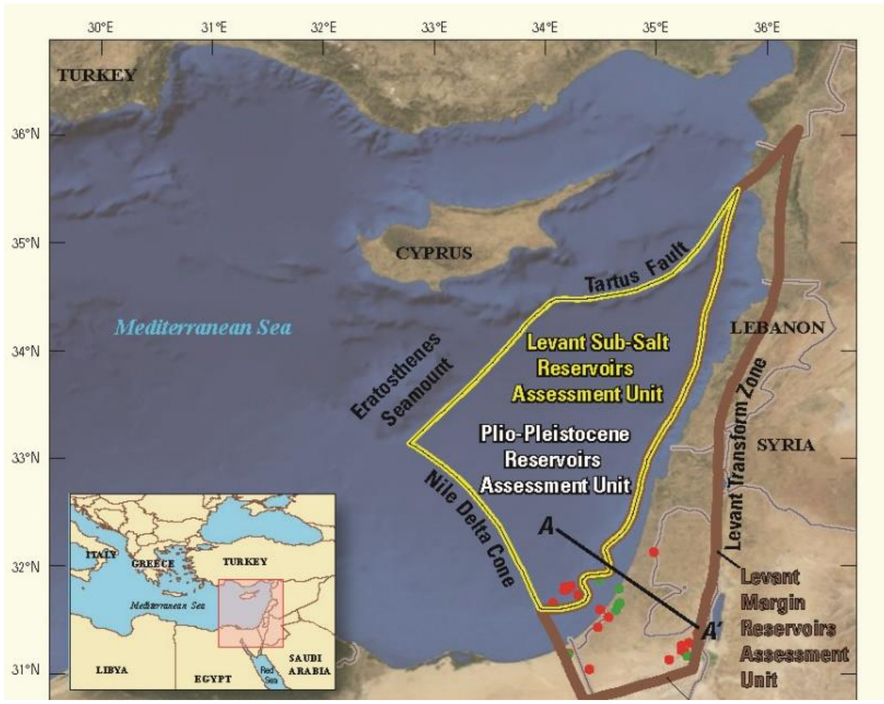


Figure 2: Location of the Levant Basin in the Eastern Mediterranean.

The first successful and significant gas discoveries in the Levant basin were Tamar field in 2009, Aphrodite field in 2011, and Leviathan field in 2013 (Sukkarieh, 2018a). Later in 2015, giant Zohr field, estimated to contain 30 Tcf of Natural Gas, was discovered in Egypt. Accordingly, interest in the Levant basin increased as experts expected to find additional gas reserves in the region (Ghafar, 2015). Lately, Cyprus witnessed the discovery of the Calypso field in 2018, estimated to contain 6-8 tcf, and the Glafcos field in 2019, estimated to contain 5-8 tcf (Koukakis, 2019). Further information about discoveries are summarized in table 1.

Although no exploration and production activities are taking place in the offshore of Syria, a country also located on the East Mediterranean, Syria holds 8.5 tcf of onshore natural gas reserves (EIA, 2011). According to ministerial sources, Syria is expecting is starting offshore exploration activities, and expecting commercial production to start by 2023 (Azhari, 2019).

Table 1: Major natural gas fields discovered in the Levant Basin.

	Field Name	Discoveries till date (tcf)	Year of discovery	Operator
Cyprus	Aphrodite	3.6-6	2011	Noble Energy
	Calypso	6-8	2018	Eni
	Glafcos[7]	5-8	2019	Exxon mobile
Lebanon[8]	-	0	-	Total
Syria	-	0	-	Russian Companies
Palestine[9]	Gaza Marine	1	2000	-
"Israel"/ Occupied Territories	Noa and Mary-B	1.5	1999	-
	Tamar	9.7	2009	Noble Energy
	Myra	4.2	2010	Energean Oil & Gas
	Sara	1.47	2010	Energean Oil & Gas
	Leviathan[10]	19	2010	Noble Energy
	Karish	1.8	2013	Energean Oil & Gas
Egypt	Zohr[11]	30	2015	Eni

[7] The discovery of an additional 5 to 8 tcf, in February 2019 have raised hopes of exporting gas by 2022 (Smith, 2019).

[8] Till date, no discoveries have been announced. Exploration wells are expected to be drilled in late 2019.

[9] Resource development was obstructed by "Israelis" in 2000. Therefore, the resource remains unaddressed. Additional exploration activities did not take place till the date of the writing.

[10] Development of the Leviathan field and production of gas is expected to be completed by end of 2019.

[11] Rapid (Record Breaking) development of the Zohr field enabled the production of natural gas to start by 2017.

Soon after the discovery of natural gas, companies contract gas for sale before further development. Gas discovered in the East Med region have already been contracted for sale in the immediate neighborhood. However, discoveries of additional gas fields could create a need for new export routes (Tsafos, 2019).

In 2016, Jordan's National Electric Power Company (NEPCO) signed a 15 years contract with Noble Energy to purchase 3 bcm/year from the Leviathan field, a deal worth $10 billion (TJT, 2019a). The first gas is expected to be delivered in early 2020 (Tayseer & Benmeleh, 2018). However, protestors called the Lower House and the government to terminate the gas deal. Soon after, the Lower house declared its rejection of the gas deal, and requested to cancel the agreement with "Zionist Entities" at any cost (TJT, 2019b).

In parallel, Egyptians and "Israelis" signed a $15 billion agreement to export natural gas to Egypt in the next decade, and both parties are discussing the possibility of building a new underwater pipeline to export additional quantities of natural gas to Egypt since the latter could become an LNG hub in the East Mediterranean (Magdy, 2019).

C. Prospects of Natural Gas Reserves in Lebanon – Brief history

Up to date, Lebanon is a net importer of fuel since no indigenous hydrocarbon resources have been discovered yet (Hamdan & Khoury, 2015). However, the country is likely to be a newcomer to the "Gas Producers Club" since Lebanon's potential for discovering natural gas reserves in its offshore territory is high, and its reserves are estimated to range between 25 and 96 tcf (Khraiche, 2017).

To manage the upstream oil and gas sector, the Lebanese Petroleum Administration (LPA) was established in 2012. The role of LPA covers technical, regulatory, supervisory, and planning activities across the value chain of the petroleum industry (LPA, 2018). The slow governmental progress to develop Lebanon's petroleum resources have been criticized; however, greater risks could have been involved if an accelerated path was adopted. Although the political process is slow, its role was perceived as creating consensus regarding policy outcomes (Marcel, 2013).

The first bidding round for exploration and production of hydrocarbons from 5 offshore blocks was announced in 2013. The tender took four years to be closed due to political reasons, in addition to missing legislations and regulations. In specific, the bidding process could not be completed until three documents – a decree to specify the ender protocol and model EPA, a decree to define offshore blocks, and the petroleum tax law – were approved (Sukkarieh, 2018b). The Council of ministers approved to award a consortium composed of three International Oil Companies (IOC) - namely France's Total, Italy's Eni, and Russia's Novatek - two exploration and production licenses in blocks 4 and 9 in December 2017. Figure 3 shows Lebanon's offshore blocks. After finalizing the studies and logistics, the consortium is expected to start drilling in 2019 (LPA, 2017). Based on a second licensing round, blocks 1,2,5,8 and 10 are open for bidding. Accordingly, additional exploration and production awards are expected to be approved in 2020 (LPA, 2019).

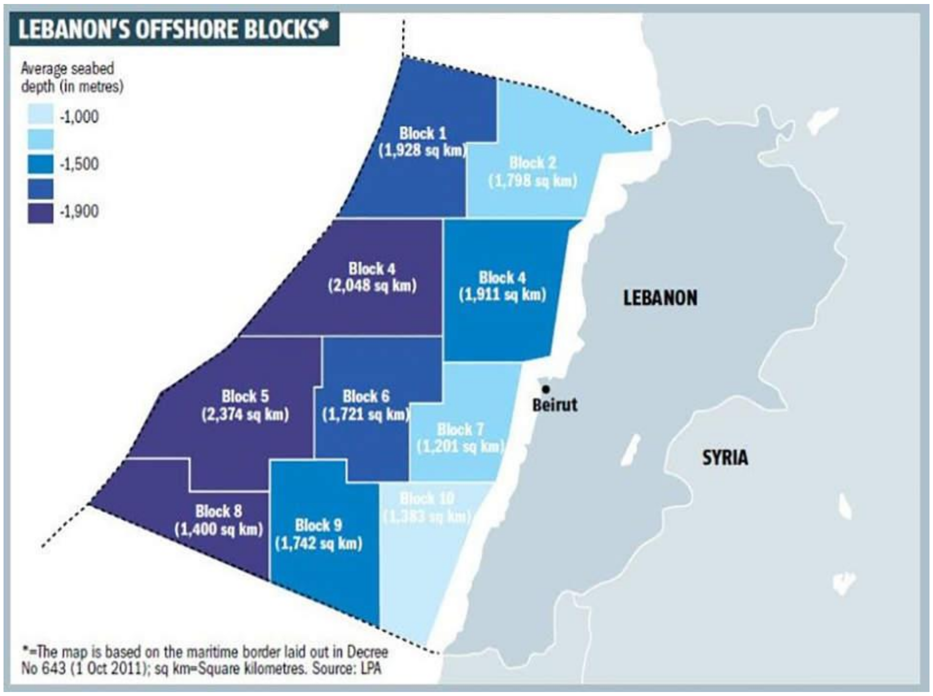


Figure 3: Lebanon’s offshore blocks.

D. Natural Gas Supply, Demand and Pipelines in Lebanon: History and Future Projections.

Lebanon’s energy system is dependent on imported fuel, where 93% of the Gwh are produced from importer diesel oil and heavy fuel oil. Among the already built power plants in Lebanon, some operate based on a combined cycle gas turbine (CCGT) technology, and could be run on natural gas. Based on an economic and environmental analysis, the use of natural gas to generate electricity in Lebanon proved to be superior to the current state of dependence on oil (Dagher & Ruble, 2011).

Lebanon aimed to import natural gas through Gasyle I, an extension of the Arab Gas Pipeline (AGP). A second offshore natural gas pipeline, Gasyle II, was expected to connect Beddawi to Zahrani, i.e. connecting coastal power plants in the North and South of

Lebanon. However, the project did not materialize (Zein, 2004). Accordingly, Gasyle I is the only gas pipeline in Lebanon.

Gasyle I is a 32 km natural gas pipeline, connecting Homs in Syria to the Deir Ammar – Beddawi power station, with a diameter of 24 inches, and a capacity of 2.2 bcm/yr. Gasyle I was expected to supply natural gas from the Syrian Petroleum Company, and costed $13.7 million. A 25 years contract was signed with Syria to supply Lebanon, initially, with 1.5 bcm/year of Natural gas (World Bank, 2004). Construction of the Gasyle I pipeline ended in 2005; however, Syrian gas was not delivered as there was no sufficient quantities to export to Lebanon (Osseiran, 2015). Therefore, a gas swapping agreement was signed between Syrian and Egyptian officials, and Lebanon's Ministry of Energy and Water (MoEW). The pipeline was activated in 2009, and Lebanon was supplied with natural gas from Egyptian Company for Natural Gas-GASCO. Accordingly, the Gasyle I pipeline became operational in September 2009, where Lebanon received 26.3 mcm/month of natural gas to fire one gas turbine in Deir Ammar power plant. Due to riots taking place in Egypt and geopolitical conflicts extended along the trajectory of the AGP, Lebanon ceased receiving Egyptian natural gas in November 2010 (ILF, 2016).

In light of the potential discovery of natural gas in the Exclusive Economic Zone (EEZ) of Lebanon, analysts have stressed on the export potential of the country if local needs prove to be lower than discoveries. However, the export possibilities of Lebanon will depend on the country's capacity to build the infrastructure to transport and/or liquefy natural gas (Saif, Atallah, Berro, & Khadouri, 2011).

A recent study was conducted to investigate necessary renewable energy and thermal capacities to supply a reliable load of electricity in Lebanon between 2019 and 2032. According to thorough technical and economic calculations, the electricity sector is expected to consume 6.88 bcm of natural gas (Boujikian, 2019). Accordingly, the projected local demand is minimal as compared with the expected quantities to be discovered. Therefore, Lebanon could be a potential supplier of natural gas. Nevertheless, the political structures in the region will play a significant role in determining future natural gas distribution and markets cooperation.

E. Natural Gas Demand and Supply in Europe and the Middle East

A global analysis of market supply and demand is needed to identify Lebanon's export partners and export destinations. Based on the brief analysis presented below, Europe, a net energy importer proves to be a great destination for Lebanese natural gas. However, other smaller markets in the region should also be considered since the cost of building infrastructure is dependent on the length of the pipelines.

Europe is a net importer of natural gas, and depends on Russia, Norway, Algeria, and Qatar to fulfill its demand (EC, 2018). According to the latest report issued by BP in 2018, Europe has imported 189.3 bcm from Russia, 109.2 bcm Norway, 43.3 bcm from Netherland, 33 bcm from Algeria, 10.8 bcm from UK, 16.2 bcm from other European countries, 8.4 bcm Azerbaijan, and 4.4 bcm from Libya, resulting in a total of 423.4 bcm of pipeline gas. In addition, Europe has imported 23.7 bcm of LNG from Qatar, 14.1 bcm from Algeria, 12.2 bcm from Nigeria, and 15.7 bcm from other countries; resulting in a total of 65.7 bcm of LNG.

Worthy to note, the average R/P ratio in Europe in 2017, including Netherlands and Norway, is estimated at 12.2 years. If no major natural gas reserves were discovered in the following years, European reserves are expected to be depleted on average before 2030. Accordingly, even if natural gas consumption in Europe does not increase dramatically, the demand for natural gas import is expected to increase in order to replace the share of current European suppliers, i.e. Norway, Netherlands, U.K, and other EU countries, to the European market.

The International Energy Agency (IEA) prepared a market report to project Natural Gas consumption growth between 2017 and 2023. Results predict a 11.4 bcm decrease in natural gas consumption in Europe by 2023 (IEA, 2019). Although consumption of natural gas is projected to shrink, demand for imported natural gas is projected to grow for two main reasons: first is the decline of domestic production due to the progressive depletion of the north sea and Groningen field (IEA, 2019; Tagliapietra, 2017b), and second is the retirement of nuclear and coal fired power plants. Gas Fired power plants are expected to replace the retired power plants in the next decade (Dezem, 2019).

The same IEA report predicted and increase of 80.4 bcm in natural gas consumption growth for the Middle East between 2017 and 2023, led by increasing demand in power generation, seawater desalination, and industrial processes (IEA, 2019).

Energy Insights by Mckinsey, had a different analysis regarding natural gas demand. The leading global market analytics and intelligence group, Energy Insights, has performed a modelling simulations based on current technological, demographic and legal trends to project natural gas growth through 2035 in the global gas market. Results showed a global increase in natural gas demand between 2017 and 2035. Asia, and in particular China is expected to lead the growth demand, adding 340 bcm by 2035. Africa is expected to require an additional 70 bcm. The Middle East and the US are expected demand an additional 100 bcm each; while Europe and Russia are expected to demand together an additional 20 bcm by 2035. Details regarding results of the simulation are shown in figure 4 (Mckinsey, 2018).

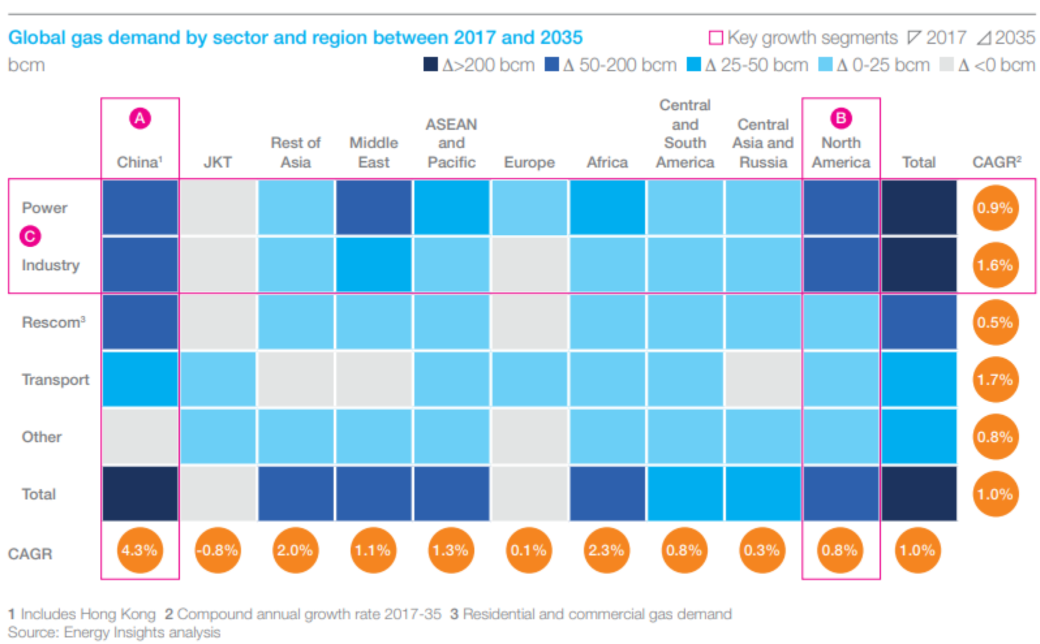


Figure 4 Global Gas demand by region and sector between 2017 and 2035.

Both analysis reflect a slight increase in European natural gas demand. Given that some of the current producers' reserves are expected to be depleted within a decade, European consumers are expected to find new sources of natural gas to replace Norway and Netherland's share. On the other hand, the Middle East is also expected to witness an increase in natural gas demand in both analyses.

Accordingly, East Mediterranean gas producers, such as Lebanon, could play a role in filling the gap in regional Mediterranean markets or farther European Markets. For the latter, cost considerations could drive towards increasing imports from traditional suppliers such as Russia, a country that is already building new pipelines towards Europe. Yet, the political agenda has always carried the security of European natural gas supplies as one of its highly important topics. In 2008, the EU launched a policy to diversify its gas imports due to concerns related to energy security, and announced its support to a new Southern Gas Corridor (SGC). SGC aims to import natural gas from Middle Eastern and Caspian gas producers to Europe in order to diversify the energy sources (Tagliapietra, 2015). However, and over the long term, the World Energy Outlook report issued by the International Energy Agency projects that Russia will remain the main exporter of natural gas into Europe as Russian gas would account for one third of European gas needs until 2040 (IEA, 2018).

The Third Energy Package (TEP) policy entered into force by 2011 in the EU and established several rule to regulate the existing and incremental pipeline capacity. By 2013, an additional Capacity Allocation Mechanism Network Code (CAM NC) was adopted and defined the regulatory procedures for existing pipeline capacity. Later in 2017, CAM NC provided a new set of regulations governing allocation, construction, and payment for the incremental pipeline capacity. As any new pipeline have to undergo a complex and unclear regulatory process, the number of new pipelines in the EU is expected to be minimal. The alternative, i.e. importing natural gas via LNG terminals, is expected to be much easier (Yafimava, 2018)

Given that EU countries are interested in diversifying their supply of natural gas, and reducing price of natural gas, EU is issuing policies to increase market liberalization, and transform the market into a hub based market. A shift in the market structure does not imply that long term contracts (LTCs) will disappear. LTCs will exist to maintain security of supply and demand for buyers and sellers; however, the price is expected to be determined by the market (Stern & Rogers, 2011).

F. Major Recent Existing and Planned Pipeline Infrastructure to Deliver Natural Gas from Russia, the Caspian and East Mediterranean Region

1. The Caspian Region and Russia

Table 2 and figure 5 show the major, and relatively new, natural gas pipelines designed to transport natural from Russia and the Caspian Region to the EU (EIA, 2015). Additional qualitative details are provided below.

a. <u>Nabucco Pipeline</u>

In light of Russian-Ukrainian-European crisis regarding natural gas, and the announcement of the SGC, EU supported the Nabucco pipeline project, designed to carry

Azerbaijani natural gas through Turkmenistan, Iraq, Iran, Turkey, to Southeast and central Europe (Petersen, 2009). Soon after the announcement, Nabucco gained financial and political support, and became a “flagship project of the Southern Gas Corridor” (Tagliapietra, 2015). However, the project was officially canceled in 2013 (Loskot-Strachota & Lasocki, 2013).

While some argue that Nabucco failed because of geopolitical factors and the Gazprom-Kremlin moves, others attribute the failure to the lack of commitment of major EU energy companies, the latter who believed there was no sufficient gas available to feed the large pipeline (Skalamera, 2018). In short, although Nabucco received strong political support, it received little commercial interest.

b. BTE-TANAP-TAP Pipelines

South Caucasus pipeline, also known as the BTE pipeline, was commissioned in 2006, and transports natural gas from Shah Deniz gas field in Azerbaijan, via Georgia, to Turkey (BP, 2019). While developing its natural gas fields, Azerbaijan conceptualized its project to export its natural gas to Turkey, then Europe. The Trans-Anatolian Pipeline (TANAP) was designed to connect the existing South Caucasus pipeline with the Turkey-Greece border. The project is expected to be completed by 2019, will deliver 6 bcm/year to Turkey, and 10 bcm/year to Europe. To better link TANAP with European markets, the Trans-Adriatic pipeline (TAP) was selected to carry gas from TANAP in Greece, to Albania, then Italy (EIB, 2019).

c. <u>Turkish Stream</u>

Turkish Stream, also known as TurkStream, is a new export gas pipeline, currently under construction. The pipeline stretches over 930 km from Russia to Turkey via the Black Sea. The pipeline is made of two strings, each with a capacity of 15.75 bcm. The first is intended for Turkish markets, while the second is expected to deliver gas for South and Southeastern Europe. The project is expected to be operational in late 2019 (Gazprom, 2019)

d. <u>South Stream</u>

South Stream was a 930 km pipeline project dedicated to transport a maximum capacity of 63 bcm of natural gas from Russia via the black sea to Bulgaria, and via Serbia to Hungary and Slovenia, and ends in Austria (Boersma, 2014). Construction started in 2013; however, the European Commission saw that the project is breaking competition rules in the EU, and was accordingly suspended in 2014 (BBC, 2014).

Table 2 Details of major new transit pipelines from Russia and the Caspian Region to Europe.

Pipeline	Trajectory	Capacity (bcm/year)	Length (Km)	Status
Nabucco	Azerbaijan, Turkmenistan, Iraq, Iran, Turkey, to Bulgaria,	63	930	Proposed in 2002 Project cancelled in 2013.

	Romania, Hungary, Austria			
South Stream	Russia – Black Sea – Bulgaria – Serbia – Hungary – Slovenia – Austria	10 – can be scaled to 23	NA	Construction started in 2013. Project Suspended in 2014.
BTE (South Caucasus)	Azerbaijan – Georgia - Turkey	25	692	Commissioned in 2006.
TANAP (Trans Anatolian Pipeline)	Turkey – Greece	16	1841	Construction started in 2015 Expected to be completed by 2019.
TAP (Trans Adriatic Pipeline)	Greece – Albania – Italy	10-20	878	Project announced in 2003. Construction started in 2015. Expected to be completed in 2020.
Turkish Stream	Russia – black sea – Turkey	2 lines, each 15.75 bcm/year	930	Expected to be completed by 2019.

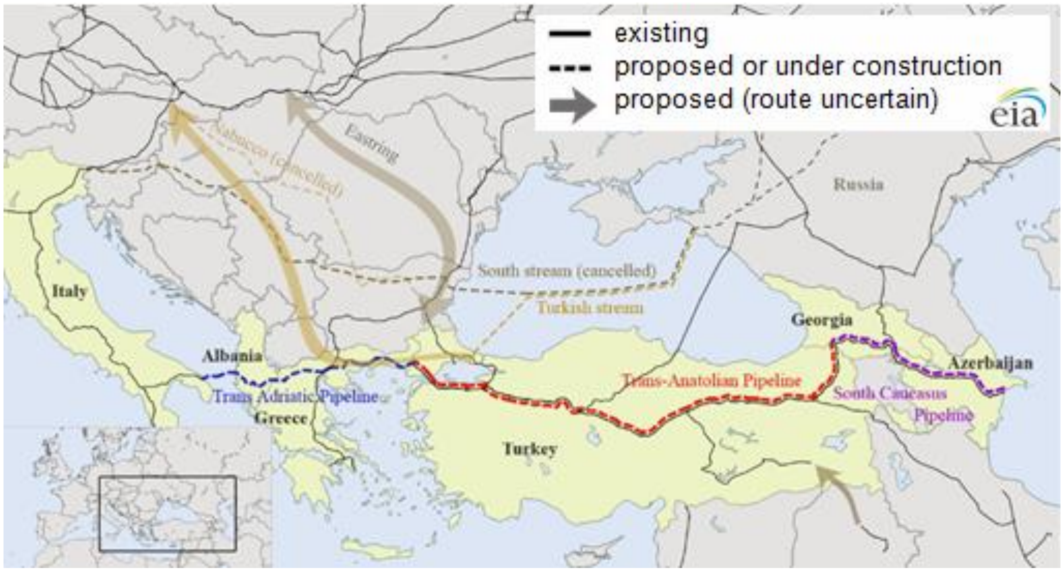


Figure 5 Major new transit pipelines from Russia and the Caspian Region to Europe.

2- The East Mediterranean Region

a. <u>"Israel"-Turkey pipeline</u>

A pipeline with a capacity of 10 bcm/year was proposed to deliver natural gas from Leviathan's gas field in "Israel" to Turkey. However, the discussion has stopped due to political conflict between Turkey and "Israel" in 2014. Moreover, in light of the complicated relationship between Turkey and Cyprus, "Israel" would be hesitant to move forward with such a pipeline project (NGW, 2014).

b. <u>Cyprus to Egypt Pipeline</u>

In a recent statement, Cyprus and Egypt discussed building a new subsea pipeline to connect Cyprus' gas resources with Egypt's two LNG facilities. Notably, the EU supported the planned pipeline. The main aim of the plan is transporting the Cypriot natural gas to Egypt, and then re-exporting the resource to mainly Europe, and potentially other Asian markets, in the form of LNG (S&P Global, 2018).

c. Arab Gas Pipeline

Arab Gas Pipeline (AGP) is a 1200 Km pipeline designed to export Natural Gas from Egypt, to Jordan, Syria, and Lebanon. An additional branch was added to export natural gas to "Israel". The pipeline was built in phases with a total capacity of 10.3 bcm, and was completed in 2009 (Ministry of Petroleum, 2010). Details regarding different sections of the pipeline are presented in table 3.

After the fall of the Mubarak Regime in Egypt in 2011, the Arab Gas pipeline witnessed around 25 sabotage attacks to cut Egyptian exports to "Israel" and shut the pipeline (BBC, 2011; JT, 2019a). Egypt was supposed to export 2.1 bcm/year to "Israel" up to 2028. However, Egyptian state entities cancelled the agreement due to a force majeure. The matter was referred to Arbitration, where Egypt was ruled against and fined $2 billion. In 2015, the consortium operating Tamar's field announced a preliminary agreement to convert the AGP flow and export 5 bcm of natural gas to Egypt; however, import was not allowed to date (SW, 2019). In contrast, Egyptian gas supply to Jordan resumed officially in 2019 (JT, 2019b). Talks between Egypt and "Israel" are in progress to build a new offshore pipeline to transport natural gas from Leviathan and Tamar to the existing LNG plants in Egypt for processing and re-export (Magdy, 2019).

Table 3: Diameter and length of different sections of the AGP.

From	To	Diameter (inch)	Length (Km)
Arish	Aqaba	36	265
Aqaba	El Rehab	36	390
El Rehab	Jordan – Syria Border	36	30
Jordan – Syria border	Homs	36	330
Lebanon – Syria border	Tripoli	24	33

d. Islamic pipeline

The Islamic pipeline project, designed to carry up to 25 bcm of Natural Gas, from Iran to Iraq, Syria was suggested (Reuters, 2011). However, the project suffered from major funding problems, in addition to the complex and deteriorating security and political situation in Iraq and Syria (NGW, 2013). Therefore, the project remains unbuilt till date.

e. East Med Pipeline

The East Med pipeline, as proposed, is a 2000 km long project expected to connect the offshore Mediterranean, in particular "Israel", Cyprus, and Crete with mainland Greece to Italy. The 10 bcm project is expected to cost around $6-7 billion, and is supported by the EU and U.S. (Debre, 2018). The current discoveries in the region, i.e. the Leviathan, Tamar, and Aphrodite fields in "Israel" and Cyprus could supply the local market. However, the East Med pipeline was proposed and justified based on geopolitical and security arguments, and a desire in developing beneficial projects with the EU (Gas Strategies, 2019).

East Med pipeline is proposed by IGI Poseidon S.A., a company equally owned by Edison International Holding[12] and DEPA[13] S.A (Edison, 2017). To fill a large pipeline such as the East Med, gas should be aggregated from different fields; i.e. from different owners or countries. So far, it not clear if a buyer from Europe or a gas producer from the East Med region is willing to play such an essential role for a multinational pipeline (Tsafos, 2019). A final decision regarding the construction of the East Med pipeline was expected in early 2019 (Bousso, 2018). Yet, no official timeline or plan was announced till date.

Unlike the TANAP-TAP pipeline, the East Med pipeline does not pass through Turkey, a country which is already acting as a transit country for Russian and Azerbaijani natural gas transported to Europe. As a consequence, the East Med pipeline offers an alternative route to diversify EU's energy sources and paths (Marketos, 2018).

As the proposed pipeline passes through the Greek Cypriot, President of the Turkish republic of Northern Cyprus mentioned that "the pipeline project does not offer a route to peace" as the project ignore the sovereign rights of nationals living in the north of Cyprus (Daily Sabah, 2018). Moreover, Lebanese Foreign Minister Gebran Bassil sent a letter to Greek and Cyprus' Foreign Ministers, EU foreign Policy Chief, and United Nations Secretary General. Bassil called involved countries to respect Lebanon's sovereignty and

[12] Edison is an Italian energy group.

[13] DEPA is Greece's natural gas firm.

abide by the coordinates sent to the secretary general of the U.N. and international maritime laws as they construct the pipeline (The Daily Star, 2019a).[14]

Importantly, the rationale behind developing such a pipeline is based on three assumptions: first is that EU's demand for natural gas will increase, second is that sufficient volumes of natural gas will be available for export from the East Mediterranean, and third is that the East Mediterranean's natural gas will be favored among other traditional suppliers to fill the gap in European demand (Tagliapietra, 2017a).

Similar long pipeline projects, such as Nabucco, were also supported by the EU; however, these did not materialize and were considered as wishful thinking from the EU (Tagliapietra, 2017b). Yet, the final decision to build or forgo the East Med pipeline will be impacted by a combination economic and political arguments.

f. Other Forms of the East Med Pipeline

Ruble, a scholar specializing in energy economics, has proposed a new form for the East Med pipeline: a cooperation between what she calls as "ECIL countries", namely

[14] The East Med pipeline, as proposed, is unlikely to pass through the Lebanese territories as delineated by Lebanon for a diplomatic and security reason: from a diplomatic point of view, Lebanese Foreign Minister Gebran Bassil has already communicated the Lebanese concern with involved parties. Therefore, it would be difficult to proceed with any plan to build the pipeline through the claimed Lebanese territories without further mediation or other types of international legal procedures. From a security point of view, construction of the pipeline in Lebanese territories will place the pipeline under the threat of missiles attack from Hezbollah. Nasrallah, Secretary General of Hezbollah, has threatened to bomb "Israeli" gas facilities in case Lebanese territories were transgressed. Following the same rational, any pipeline built to transport "Israeli" gas is under threat, if Hezbollah proves possession of adequate military technology. Such a costly project to deliver Gas to EU will not be built without further measures of security. Otherwise, the project is expected to be built on undisputed areas.

Egypt, Cyprus, “Israel” and Lebanon. As Ruble suggested, “ECIL” shall export natural gas through a common pipeline. i.e. the East Med pipeline, to Europe. Based on her economic model, a project with an average capacity of 15 bcm/year is expected to cost $ 6.3 billion, while a project with an average capacity of 25 bcm/year is expected to cost $ 8.6 billion. The author argues that, under such conditions, “The East Med pipeline gas supplies would be marginally competitive in Southern Europe” (Ruble, 2017).

The cost suggested by Ruble is cheaper than the currently announced cost for the East Med pipeline: Ruble’s cost for a pipeline with a capacity of 15 bcm/year ($6.3 billion) falls within the range suggested for the currently proposed East Med pipeline with a smaller capacity of 10 bcm/year ($6-7 billion). Therefore, her conclusion regarding the competitiveness of the East Med pipeline in Southern Europe is questionable since the volumes she considers to calculate the revenues are 50% higher, and thus the sales are 50% higher than the ones actually proposed.

In addition, a cooperation between Lebanon and “Israel”, whether direct or indirect, from a Lebanese legal perspective, is not realistic in the presented form by Ruble. The statement stems from a Lebanese law, which was approved by the parliament in 1955, and published in the official gazette by the time. According to the first article of the law, it is forbidden for any natural or legal person to enter into contracts directly or through mediation agreements with entities or people living in “Israel”, or nationals of “Israel”, or people working for it or for its benefits. The law is applicable even if the topic of the deal was commercial, financial, or otherwise natured agreement. It is also forbidden to deal with national or foreign Companies and establishments which have factories, collection branches, or agencies in “Israel” since these are considered as organizations or people with whom is forbidden to deal with (Lebanese University, 1955).

Moreover, one of the rationales behind the East Med pipeline, as initially proposed by “Israel”, is “moderating Arab influence in Europe” (Verocy, 2018). As a result, and from an “Israeli” perspective, the project is unlikely to proceed as a regional cooperation between “Israel” and other Arab countries.

CHAPTER III

MAJOR GEOPOLITICAL PLAYERS AFFECTING THE DEVELOPMENT OF NATURAL GAS RESERVES IN THE EAST MEDITERRANEAN

Although the US, Russia, Iran, Gulf countries, and many EU member states are geographically far from the East Mediterranean, each has a geopolitical role in shaping the development of natural gas reserves in the Levant basin.

When it comes to natural gas resources, Russia has been the largest producer of natural gas. Most of the Russian gas is supplied to Europe by pipelines, passing via Ukraine as a transit country. Accordingly, the relationship between Russia and Europe has been characterized by a dynamic interdependency (Harsem & Harald Claes, 2013). After escalation of transit problems between Russia and Ukraine in 2006 and 2009, many EU countries have witnessed energy shortages. Therefore, EU countries initiated a strategy to diversify their suppliers of natural gas, and include new suppliers such as Azerbaijan (Bilgin, 2009, 2011). However, in light of the transit crisis, Russia has built a significant surplus pipeline capacity to enhance its energy security, minimize transit risks, and ensure competitiveness of Russian Gas in Europe in the long term (Vatansever, 2017). As opposed to the political desire, the Russian export share of gas to Europe is not expected to decline dramatically (Mitrova, Boersma, & Galkina, 2016). One possible explanation of the multi-faced EU-Russia gas relationship is that the economic interests of large energy companies takes precedence over other policy and political considerations (Skalamera, 2016).

As the geopolitical conflict between Washington and Moscow evolve, the U.S. policy is driving towards reducing Russian State revenues from the energy industry, as well as reducing Europe's dependence on energy imports from Russia (Lohmann & Westphal, 2019). Russia is trying to hold its strong position in European market, not only by building its own pipelines projects, but also by obtaining shares in the East Mediterranean energy projects, with a specific focus on natural gas. Soon after the discovery of the Zohr field in Egypt, Russia bought 30% of ENI's stake, the Italian company operating the Zohr field. Similarly, Russia bought a 20% stake of the consortium leading the exploration and production activities in Lebanese waters (Pierini, 2019). Moreover, a Russia was awarded exclusive rights to produce oil and gas in Syria, starting in 2017 (Koduvayur & Everett, 2019). On a broader aspect as well, Russia's Rosneft oil company signed a new agreement in 2019 to operate and expand Tripoli's oil storage tanks in Lebanon for 20 years (The Daily Star, 2019c). The purchase of an old center to store oil was perceived as a political message asserting Russia's influence across the Middle East region (Rose & Brown, 2019).

Russia has been also militarily involved in the Syrian civil war, along with Iran, to support Al-Assad government. Although Russia has achieved tangible military successes, Moscow is getting more isolated from the rest of the world (Souleimanov & Dzutsati, 2018). The US was also involved in Syria; yet, Russia and Iran were better positioned to influence the course of the Syrian civil war, from the beginning (Bolan, 2018). The increased military support to Syria is justified via many reasons, including Russian companies' interests in the potential gas and oil reserves in offshore Syria (Kozhanov, 2015).

The Iranian outlook for natural gas resources is quite different, as Iran is subject to major challenges, on a global level. Iran has been facing economic and political sanctions imposed by Western Powers, such as the US and EU, and the United Nations Security Council, since 1979 after the change of regime. In the energy sector, those measures prohibited energy investments in Iran, and embargoed purchase, import, and transport of Iranian hydrocarbons. As western technology and foreign capital is mostly inaccessible in Iran, development of gas fields became challenging. As a consequence, Iran was not able to develop LNG terminals, while Qatar has emerged as the largest LNG supplier in the region, and the world (Dudlák, 2018). After signing the Joint Comprehensive plan of Action (JCPOA) in 2015, sanctions on Iran were lifted. However, in 2018, the US withdrew from the JCPOA and re-imposed all the sanctions which were waived, and targeted the energy, shipbuilding and shipping, and financial sectors (USDT, 2019). Although Iran possesses significant natural gas reserves, sanctions have affected the country's ability to develop its own reserves, let alone the country's potential to influencing the natural gas market. Accordingly, Iran's role in the natural gas market is limited in light of the imposed sanctions. However, future diplomatic efforts can reshape Iran's relationship with the EU and the West, as the relationship between the countries has been dynamic, and changed several times over the past decades. While the sanctions persist at the date of the writing, these may be lifted in the future, and the role of Iran in natural gas market may change.

Turkey, exhibiting multiple cooperation strategies with Russia, the US, and EU, desires to become a regional gas hub given its geographic location and growing energy demand. With the development of Turkstream and TANAP, Turkey is becoming a key transit country to transport natural gas to Europe (Rzayeva, 2018). The concept of developing a natural gas hub in Turkey could materialize in the medium to long term if infrastructure was expanded, and domestic regulative, infrastructural, commercial problems were resolved (Austvik & Rzayeva, 2017). Even though Turkey is close from the producers of natural gas, as well as the consumers, the region faces significant disputes, and pipelines are prone to geopolitical risks (Erşen & Çelikpala, 2019). As the major conflict between Turkey and Cyprus persist regarding the rights of Turkish Cypriots to share the offshore resources of the Island, and the tension between Turkey and Syria escalates, current producers of natural gas that could contribute to the SGC, may offer other strategic routes bypassing Turkey.

On the other axis, and soon after the discovery of Tamar and Leviathan fields in the East Mediterranean, an energy security report was prepared and submitted to the Strategic Studies Institute and U.S. army War College Press. Beyond “Israel”, key geopolitical players in the Middle East region were considered Lebanon and Syria, both accounting in the calculations of U.S. vis a vis Iran and Russia. According to the report, “Israel” and Cyprus were considered strategic political and military allies to the U.S., and pillars of the U.S. foreign policy in the Middle East (El-Katiri & El-Katiri, 2014).

The report explored scenarios for exporting “Israeli” and Cypriot Gas via individual LNGs, an LNG hub in Cyprus, the latter considered a safe location in the Middle East, and pipelines to either turkey or surrounding Arab countries, i.e. Palestine, Egypt and Jordan. The report refers to the Arab - “Israeli” pipeline as the “peace pipeline” which promotes higher security for U.S. interest, and enhances “Israel’s” safety. However, politics was considered a major block to the “peace pipeline” (El-Katiri & El-Katiri, 2014). Such a claim could be justified by a historical and factual analysis: “Israel” produced 60% of its natural gas demand, and used to import the remaining 40% of from Egypt, at a preferential price, via an offshore pipeline (Siddig, Grethe, & Abdelwahab, 2016). Sales below the market price to “Israel” started officially in 2008, and was expected to last for 15 years. Since the Egyptian revolution in 2011, natural gas supplies from Egypt to “Israel” has been prone to disruption due to public discontent. While exploiting new gas fields is expected to enable “Israel” to export natural gas, and reduce its import from Egypt (Siddig & Grethe, 2014), the “peace” pipeline is likely to face sabotage and other significant political hurdles.

On the other hand, according to the same report, the regional pipeline to turkey was perceived to face lower political hurdle; therefore, the Turkey pipeline was considered more probable in the medium term (El-Katiri & El-Katiri, 2014). Worthy to note, an offshore pipeline to Turkey is expected to cross Cyprus’ EEZ. Given the complex Cypriot-Turkish knot, as well as tense relations between Turkey and “Israel”, a pipeline to Turkey is also expected to face significant political challenges.

According to a different political reading of the situation, current “Israeli” production was considered sufficient to meet “Israel’s” need. While Tamar field is producing, and Leviathan is under development, discovery of greater volumes would enhance economic profitability of exporting natural gas. From a financial and political point of view, Egypt was considered as the most realistic export option, given the geographic proximity and, apparently, the close intelligence and military contacts between “Israel” and Egypt (Henderson, 2017).

US interventions in the Middle East area will be driven by the US interests and were perceived to "shape the way in which natural gas resources define the East Mediterranean regional security landscape". As Russia is exhibiting an interest in the development of gas resources in the Levantine basin, Russian interventions have potential to change alliances in the region and break stability (El-Katiri & El-Katiri, 2014). Given the suggested framework, the US could share its experience in strategic communication and information operation with Middle Eastern allies to create public support for a negotiated regional cooperation and gas trading framework. While diplomacy is the first support measure, military US interventions could be used, if needed (El-Katiri & El-Katiri, 2014).

Despite the small area of Lebanon and its limited economic potential, the country has attracted international attention due to its geo-strategic location in the Middle East (Shadbolt & Macguire, 2012). As mentioned in a Congressional Research Service Report, "Lebanon is an important factor in U.S. calculations regarding regional security, particularly regarding "Israel" and Iran" (Blanchard, 2014). One of the recent US interventions in the Levantine basin relates to the maritime border challenge between Lebanon and "Israel". The maritime dispute appeared in 2010, when "Israel" and Cyprus signed an agreement to delineate their maritime borders. According to the presented maps, an overlap area of 860 km^2 was claimed by Lebanon and "Israel". Although Lebanon adopted sound legislations to establish the limits of its maritime zone, and provided data on coordinates with the United Nations in 2007, following obligations set in the United Nations Convention on Law of the Sea (UNCLOS), the steps are considered unilateral according to international law. Therefore, "unilateral claims cannot have legal effects on third parties" (Dupont, 2019). Although Cyprus offered to mediate negotiations between Lebanon and "Israel" regarding the disputed zone, the US was the sole player investigating this topic. In 2011, the US diplomat Frederick Hoff proposed splitting the disputed area, where Lebanon will acquire 550 Km^2 out of the 860 km^2. Yet, the Lebanese government rejected Hoff's proposal (Lebanon Gas News, 2018). US efforts were subsequently continued by David Satterfield, Acting US Assistant Secretary of State for Near Eastern Affairs to mediate finding a solution to the maritime border dispute (TDS, 2019b). So far, Lebanon did not accept American proposals, and accepted to demarcate maritime boundaries in Southern Lebanon under UN supervision (TDS, 2019a) .

CHAPTER IV

COOPERATION IN THE EAST MEDITERRANEAN BASIN

Although the Levantine basin is expected to hold 122 tcf of natural gas, volumes will be distributed over many countries. Therefore, the economic potential of each individual country is likely to be challenged by the modest volumes encompassed within its EEZ. However, in case of cooperation, the economic benefit could increase as the available aggregate volumes could render the economic profitability of export infrastructure higher. Following a similar rationale, Eastern Mediterranean countries have met in Egypt, in early 2019, and agreed to create a forum for regional gas markets in order to offer competitive prices, cut infrastructure costs, and transform the Eastern Mediterranean area into a new energy hub. Accordingly, Egypt, Greece, Cyprus, Italy, Jordan, Palestine, and “Israel” launched the forum (Reuters, 2019). Beside Syria, the regional forum has excluded two major players: Lebanon and Turkey. Lebanon’s main obstacle in joining the East Mediterranean Gas Forum (EMGF) directly or through a mediator was involvement of “Israel”. Therefore, Lebanon will not be involved in EMGF, for the near future at least (Lebanon Gas and Oil, 2019). Worthy to note, the EMFG is not an exclusively closed club, and other countries could join in the future (Sukkarieh, 2019).

EMGF was perceived as a move to exclude Turkey’s potential in becoming a regional energy hub (Al Monitor, 2019). As a reaction to excluding Lebanon and being left out, a suggestion has been made to form another forum comprised of the countries which were excluded, i.e., Turkey, Syria, Iraq, and Iran (Grandchamps, 2019; Sukkarieh, 2019).

Lebanon has been officially announcing a non-interference policy regarding conflicts in the region to maintain internal stability. Given that the EMFG, and the second suggested forum represent a quite clear alienation with different axis influencing the region, a wise approach would be strengthening relations with various regional players, as Lebanon's national interests in maximizing the economic benefits of potential hydrocarbon discoveries, and preserving national stability are not exclusively in neither the East or the West.

CHAPTER V

LEBANON'S IDENTIFIED EXPORT OPTIONS IN PREVIOUS REPORTS

Lebanon plays an important role in the geostrategic perspective as the country is located in the center of the Middle East, while geographically close to Europe and North Africa. According to the LPA, Lebanon could potentially export natural gas to European and regional countries such as Turkey, Egypt, Jordan, and Syria (LPA, 2018).

Several publications identified routes to export prospective Lebanese natural gas resources. The export options are claimed to be highly sensitive to the development of natural gas production in the region, and the timing when Lebanon is ready to export its resources (Fattouh & El-Katiri, 2015). Lebanon is bordered by Syria to the East and North, Israeli Occupied Palestine to the South, and the Mediterranean Sea to the West. As Lebanon and "Israel" are in a state of war, any onshore export pipeline is expected to pass through Syria.

In all cases, three options were suggested in a report issued by Fattouh and Katiri in 2015: first is the Middle East pipeline that connects Lebanon to markets such as Jordan, Egypt, Syria and Iraq. Although Egypt and Jordan are expected to become self-sufficient by 2020, both countries might be interested in importing small volumes of natural gas. The medium terms prospect to export natural gas for Syria and Iraq were considered attractive since Lebanon used to have stable relations with those countries, and such a pathway could offer a competitive price due to regional proximity. However, the current state of war still taking place in the northern areas of Syria is a major factor affecting the physical safety of the pipeline. Second option was the Turkey and Europe pipeline, which offers a potential to export natural gas to Syria, Turkey, and then to Europe, thus making Lebanon a "European energy supplier". The third option was LNG, which could be an attractive option due to the market and contractual flexibility it offers. However, the economic viability of LNG depends on the size of the resource and the budget of the country to develop the LNG facility.

According to Fattouh and Katiri's proposal, two pipeline options were presented, both passing through Syria to Either Turkey or other Arab countries. However, none of the proposed pipeline options have suggested an offshore pipeline to export Lebanese natural gas via Cyprus to Europe. Yet, an offshore pipeline connecting Lebanon to Cyprus is also an alternative route that connects Lebanon to Europe.

From a technical perspective, offshore pipelines are subject to high crushing forces and high bending pressures. Although similar construction activities take place to construct onshore and offshore pipelines, the latter requires specific construction and design considerations, in addition to specialized methods in pipe laying, submarine protection, and tie-in/riser installation (Stewart, 2016). Therefore, the construction of onshore pipelines, as compared with offshore pipelines, is technically easier, and financially more viable. Given the technical considerations required to build an offshore pipeline, the cost of the latter is expected to be double the cost of an onshore pipeline (PPIAF, 2013).

If a pipeline was to be evaluated based on pure technical and economic considerations, then onshore routes would be preferred over offshore routes when the diameter and length of pipelines are comparable. However, energy security and political considerations are often accounted for when planning energy export infrastructure. Therefore, economically viable projects would be considered and assessed based on a combination of costs and geopolitical considerations.

The timing of the Lebanese gas export will play a major role in choosing where and how to market the natural gas, as the market could change from its today's shape. Therefore, the delay could force Lebanon to target distant markets (Fattouh & El-Katiri, 2015). Jordan, for example, has already signed a contract to import half of its natural gas demand from Egypt for 2019, and additional commitments regarding export quantities will be indicated by the end of the year (Jordan News Agency, 2019).

CHAPTER VI

PROPOSED HUBS, MARKETS, AND PIPELINES IN THE EAST MEDITERRANEAN

An energy hub is a novel and promising concept to manage multiple energy carriers in a system. As an integrated energy management system, a hub has the potential to solve some of the main encountered challenges in the energy sector, such as demand and supply management (Mohammadi et al., 2018). Initially, gas trading hubs have been developed in the U.S. in 1980s, then in the U.K. in 1990s, and later in Europe in 2000s (Shi, 2016). Natural gas trading hubs emerged in Europe after liberalization of the industry, where the set price of natural gas is believed to be determined, predominantly, by gas-to- gas competition (Hulshof, van der Maat, & Mulder, 2016). A physical hub, such as the Henry Hub in the U.S., is a specific geographical location in the network where the price of natural gas is set. On the other hand, a virtual hub, such as the National Balancing Point in the U.K., is characterized by virtual trading points, also known as the entry-exit points of the market of natural gas. The area of a virtual hub usually overlaps with boundaries of countries in Europe (Shi & Variam, 2018).

The availability of multiple pipelines that interconnects, and the presence of various trading parties are the foundation of hubs. Wholesale markets of natural gas are initially based on the need to find a balance between suppliers and shippers. Accordingly, the liquidity of the market increases, and the price risk is managed through financial instruments (Miriello & Polo, 2015). However, key elements determining success for hubs are establishment of entry-exit system, a defined role for hub operator, establishment of exchange, contract standardization, price reporting agencies, and the presence of the right mix of market players (Shi & Variam, 2018).

Although emergence of a gas trading hub is dependent on objective parameters such as market participants, traded products and traded volumes, other subjective parameters such as political will, cultural attitudes and commercial acceptance play a role in creating a gas hub (Heather, 2015). In the east Mediterranean, potential hubs for natural gas are Turkey, Greece, Spain, Italy and Egypt. Based on political, commercial, and logistical reasons, Italy and Egypt's chances of developing successful hubs are the highest (Heather, 2015).

A. Italy

In order to reach European markets, Lebanon is likely to connect with an entry-exit point of developed virtual trading hubs. In Europe, hubs are very well connected and integrated; therefore, gas can flow easily to any European destination when crossing any entry-exit point. The closet trading point to Lebanon, in terms of distance, is Punto di Scambio Virtuale (PSV) in Italy. Moreover, as compared with other Southern European countries, Italy is better connected to European destinations by pipelines. Italy has already diverse gas supplies, a factor which puts the country in a great position to become a regional hub (Heather, 2015). Therefore, we target Italy as the entry-exit point to Europe and suggest onshore and offshore routes to export Lebanese natural gas to the PSV virtual hub. We suggest three different onshore and offshore pathways leading to Italy; pathways are guided by the existing TANAP and TAP, and proposed East Med pipeline.

B. Turkey

Turkey could connect middle eastern gas suppliers to European gas consumers, and accordingly, become an energy corridor (Ozturk, Yuksel, & Ozek, 2011). Turkey's potential to become a regional natural gas hub was studied by Tagliapietra. According to his work, the author demonstrates that Turkey could become a regional gas hub in the long term, i.e. after 2025-2030, if the EU's demand for natural gas increases and a number of political, commercial, and infrastructural barriers are overcome (Tagliapietra, 2014). Unless challenges such as difficulties related to monopoly of BOTAS, rising dependence on Russia, and the liberalization of Turkey's natural gas market are resolved, Turkey is likely to remain a transit country for Azerbaijani and Russian Gas (Erşen & Çelikpala, 2019).

From another perspective, and according to the official BOTAS's forecast, Turkey's natural gas demand is expected to increase from 56.2 bcm in 2015 to 76.4 bcm in 2030. In a recent study, natural gas demand in Turkey by 2030 was estimated around 76.8 bcm based on a linear model, and 83.8 bcm based on a logistic model (Melikoglu, 2013). In other words, Turkey's natural gas demand is expected to increase by 20 to 28 bcm by 2030. Although Turkey is expected to import some of its projected demand from Russia and Azerbaijan, Turkey could potentially import additional quantities of natural gas from Lebanon to diversify its natural gas suppliers.

Therefore, we consider the possibility of Turkey becoming a market for Lebanese Natural Gas, a transit country to European destinations, and a natural gas hub in Eurasia. Accordingly, we follow the suggested extension of the AGP from Homs in Syria to Kilis in Turkey to guide the pipeline path from Lebanon to Turkey. We also follow the Trans-Anatolian (TANAP) and Trans-Adriatic Pipelines (TAP) to guide the pathway of pipelines to Europe passing via Turkey as a transit country.

C. Iraq

Iraq has been selected as a potential market due to geographic proximity. Currently, Iraq imports natural gas from Iran (BP, 2018), and could be looking for additional suppliers in the future in light of the current sanctions imposed on Iran. The Lebanon – Syria – Iraq gas pipeline trajectory has been selected based on the existing Iraq Petroleum Company (IPC) oil pipeline. The IPC pipeline is an 833 km of crude oil pipeline, and composed of three sections: 33 km across Lebanon, 424 km across Syria, and 376 km across Iraq (ILF, 2016). The pipeline was built in 1930 to transport crude oil from Kirkuk in Iraq to Syria, then to Tripoli in Lebanon; however, the pipeline has not been operational since 1976 (ILF, 2016). Given the existence of the Kirkuk-Tripoli oil pipeline which was used to transport natural gas from Iraq to Lebanon, a parallel natural gas pipeline could be built to export natural gas from Lebanon to Iraq.

D. Egypt

Egypt shows a great interest in becoming a regional energy hub; a statement backed up by the country's strategic location , the developed infrastructure to refine, and export gas (i.e. two LNG plants and AGP), and the access to suppliers and markets in the Mediterranean region (Global, 2018).

Claims have been made regarding the possibility of sending Natural Gas extracted from the East Mediterranean Basin to liquefy it in Egypt as current capacity of the two LNG plants could be expanded. The Damietta plant is a single train plant with a total capacity of 5 mt/yeat, the latter could be expanded to 10 mt/yr. The Idku plant is a two trains plant, each with a capacity of 3.6 mt/year. Accordingly, the total maximum capacity of LNG plants, including expansion of capacity, is expected to reach 17.2 mt/year.

So far no LNG hub has been established, although the topic is considered hot in the LNG industry (Shi & Variam, 2018). However, the presence of LNG facilities in Egypt is a core pillar which could amplify the role of Egypt as an LNG hub in the East Mediterranean. Therefore, we select Egypt as a potential destination for Lebanese natural gas, and we use the AGP to guide to pathway of an onshore pipeline, and suggest an alternative offshore pipeline via Cyprus' EEZ.

E. Suggested Pipelines

Based on the previous information related to hubs and markets in the East Mediterranean, we suggest eight different pipelines from Lebanon to various destinations.

We consider Tripoli as the starting point in Lebanon since Tripoli is the only city which is already connected to a natural gas pipeline, Gasyle I. Details regarding each pipeline, including the pathway, location, transit countries, destination, onshore distance, offshore distance and length inside Lebanon are shown in table 4. Whenever available, we use distances suggested in the literature. Otherwise, we suggest distances based on straight line measurements calculated using the distance measurement tool available in google maps. Worthy to note, straight lines measurements fail to account for topography. Accordingly, measures are estimates, and not precise figures of the distances. Moreover, the presented pipelines represent suggestions based on other existing pipelines, and are by no means the only plausible pathways that could emerge in the future. Table 5 shows the distances we consider between various points along the trajectories; and figure 6 shows the suggested pipelines trajectories on the map. The base map was adapted from the European network of transmission system operators for Gas (ENTSOG, 2017).

Table 4 Suggested pipelines from Lebanon to Turkey, Iraq, Egypt and Italy.

Pipeline	Pathway	Location	Transit Country (ies)	Destination Country	Onshore distance (Km)	Offshore Distance (Km)	Length inside Lebanon (km)
Pipeline 1	Tripoli - Homs - Kilis	Onshore	Syria	Turkey	311	0	33
Pipeline 2	Tripoli – Ceyhan	Offshore	Syria	Turkey	0	300	30

Pipeline 3	Tripoli - Homs – Kirkuk	Onshore	Syria	Iraq	833	0	33
Pipeline 4	Tripoli - Homs - Damascus - Amman - Aqaba - Arish	Onshore	Syria - Jordan	Egypt	1045	0	33
Pipeline 5	Tripoli - Cyprus water – Damietta	Offshore	Cyprus	Egypt	0	500	100
Pipeline 6	Tripoli - Homs - Kilis - Yozghat - Eskisehir - Biga - Kipoi – TAP	Onshore	Syria – Turkey – Albania	Italy	2359	0	33
Pipeline 7	Tripoli - Ceyhan - Yozghat- Eskisehir - Biga - Kipoi – TAP	Offshore – Onshore	Syria – Turkey – Albania	Italy	1971	300	30
Pipeline 8	Tripoli - Cyprus water Greece – Poseideon	Offshore – Onshore	Cyprus – Crete- Albania- Greece	Italy	500	1500	100

Table 5 Distances based on literature values and point measurements.

From – To	**Distance (Km)**
Tripoli – Homs	87
Homs – Kilis	224
Kilis – Yozghat	400
Tripoli – Ceyhan	300
Ceyhan – Yozghat	323

Yozghat – Eskisehir	366
Eskisehir – Biga	284
Biga – Kipoi	120
TAP	878

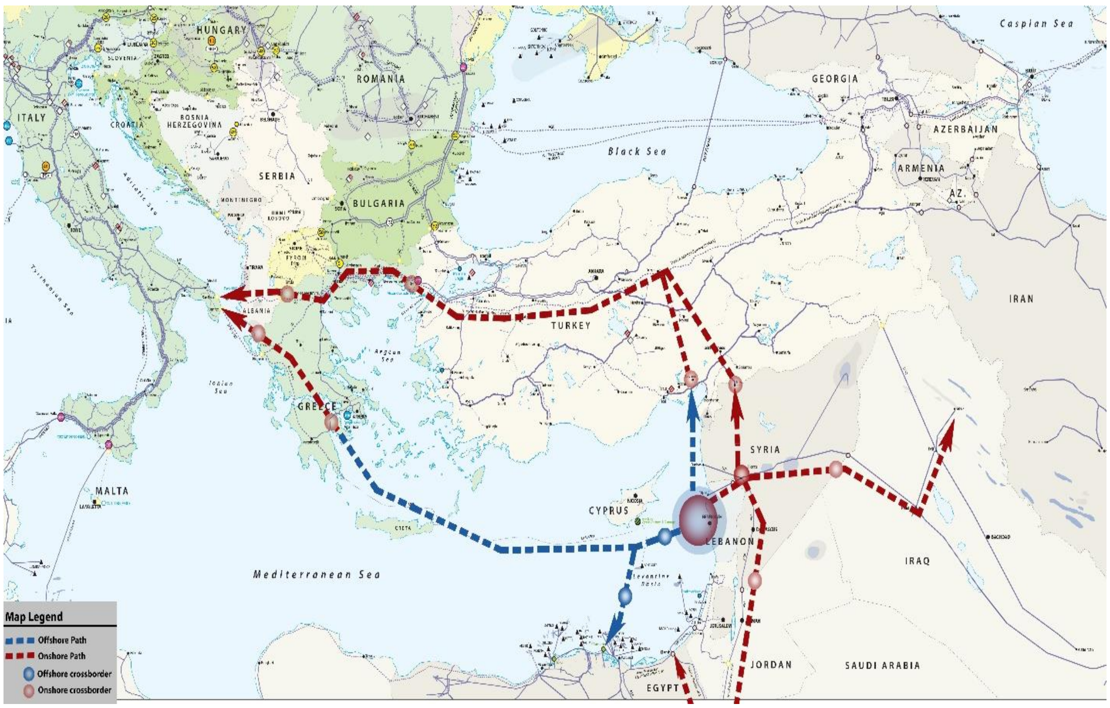


Figure 6: Suggested pipelines trajectories.

Design of pipelines includes material grade selection and pipeline sizing (wall thickness and diameter), two parameters selected based on extensive analysis of stress, span, hydrodynamic stability, corrosion and stability coating, insulation, and riser specification. The mechanical design of offshore pipelines will be affected by a list of factors including, but not limited to, water depth, water current, magnitude of the waves, reservoir performance, fluid pressure-volume-temperature (PVT) properties, fluid and water compositions, geotechnical survey data, sand particle distribution, sand concentration, and meteorological and oceanographic data. A pipeline is expected to operate during different stages of the field life, where the production profile of the field will change over time.[15] Therefore, the pipeline has to be sized to transport a volume close to the max production rate, while being easy to operate during the complete life cycle of the field (Guo, Song, Ghalambor, & Chacko, 2005). In this work; however, we estimate the size of a suggested pipeline based on general rules of thumbs to generate an estimate of the economic value of pipelines. Yet, an accurate sizing taking into consideration all previously mentioned factors shall be generated and applied for better accurate results.

Even though some studies claimed the availability of 96 tcf of natural gas in the exclusive economic zone of Lebanon, the suggestion is highly skeptical since the Levant basin is expected to contain a total of 122 tcf, out of which significant quantities were already discovered. Accordingly, we estimate the diameter of different pipelines by accounting for three different scenarios: first is the discovery of 5 tcf of natural gas, second is the discovery of 15 tcf of natural gas, and third is the discovery of 25 tcf of natural gas in Lebanon. We also assume that the lifetime of a well is around 30 years. In other words, discovered volumes are expected to be consumed locally or exported within the lifetime of the wells; i.e. 30 years.

The first, second, and third scenarios imply the availability of an average of 166.67, 500, and 833.33 bcf/year, respectively. In other units, the first scenario implies the

[15] Production profile defines the change observed in gas flowrates during the lifetime of the field. Reservoir simulations are performed by reservoir engineers to predict the production profile of a reservoir.

availability of 4.71 bcm/year; the second scenario implies the availability of 14.15 bcm/year; and the third scenario implies the availability of 23.58 bcm/year.

Transmission pipelines are built in standard sizes ranging between 16 and 56 inches. Capacity of each pipeline depends on a variety of complex factors including the inlet pressure, outlet pressure, temperature, number of compressor stations, elevation, and other factors. In this economic and geopolitical analysis, we follow the assumption that a 56-inch pipeline has a capacity of 32 bcm/year (Sadeghi, Horry, & Khazaee, 2017). In reference, we calculate the diameter of 3 different pipelines that would fit the estimated yearly available natural gas in each of the three suggested cases.[16] Results are presented in table 6.

Table 6: Diameter and capacity of proposed pipelines in 3 different cases.

Parameters	Case A: 5 tcf	Case B: 15 tcf	Case C: 25 tcf
Diameter (in)	20	36	48
Capacity (bcm/yr)	4.08	13.22	23.51

[16] Theoretically, $(Flow_1)/((Dia_1)^2) = (Flow_2)/((Dia_2)^2)$

CHAPTER VII

ECONOMIC CALCULATIONS METHOD

Siting pipeline trajectories requires extensive studies related to the topography, geology, and heritage of the location. In addition, several engineering measures are required to be taken to ensure environmental safety, and reduce hazards. Yet, construction of parallel pipelines is a common practice in the field of oil and gas. In this work, the trajectories that we suggest are mostly based on existing oil or gas pipelines trajectories, as those pathways have already been approved and used.

While pipelines and LNG plants are two means to export natural gas, this work focuses on comparing the economic profitability of the first possibility, i.e. comparing the costs of various export pipelines to Iraq, Egypt, Turkey, and Italy. Indeed, many studies attempted to evaluate the economic cost of building natural gas export pipelines. Most notably are two studies published by Ruble (Ruble, 2017) and Sadeghi et al. (Sadeghi et al., 2017). To estimate the cost of each of our suggested pipelines, we follow the methodology proposed by Sadeghi et al., as stated in their published work in 2017, since Ruble's methodology has deviated from actual announced costs, as previously mentioned. To estimate the economic potential of the pipelines, we conduct a cost-benefit analysis (CBA). As soon as the costs and the profits are calculated, the outcomes of the venture could be evaluated. We consider three economic outcomes: the net present value (NPV), the internal rate of return (IRR), and the payback period, where B_t is benefit at time t, C_t is cost at time t, and i is the discount rate.

The NPV, IRR, and payback period for each case are calculated based on a 10% discount rate, a value which has been used in various research projects related to energy in Lebanon (Trading Economics, 2019b).

$$NPV = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^t} \quad (1)$$

$$\sum_{t=0}^{n} \frac{B_t}{(1+i)^t} = \sum_{t=0}^{n} \frac{C_t}{(1+i)^t} \quad (2)$$

A. Costs Calculation

- **The Capital costs are calculated as follows:**

$$C = 0.8(4267\mu\rho) + (3 * 10^7)\alpha + 1500d \quad (3)$$

- μ is the diameter of the pipeline (inches), a factor which we estimate based on the expected available volume for export.
- δ is the length of the pipeline (km), a factor which we estimate based the distance between Lebanon and the market destination.
- α is the number of compressor stations, a factor which depends on the length of the pipeline, and the distance between compressor stations.
- d is the aggregate limit of the compressor station: where we assume that each station has 147,400 horsepower, as proposed by Sadeghi et al,.

- **Financing costs:**

Large infrastructure projects are financed through a mixture of equity and debt. For natural gas transmission pipelines, the share of equity ranges between 30 and 50%, while the share of debt ranges between 50 and 70% (Khodadad, 2014). For example, one of the latest pipelines under construction, the Trans Anatolian Pipeline (TANAP) was financed with a (28:72) share of equity to debt (World Bank, 2016).

In the latest period, the Lebanese government announced strict austerity measures to prevent economic catastrophes (The Daily Star, 2019b). Given the previous information, we assume the Lebanese government would opt for a low share of equity in the near future. Therefore, we consider that 30% of the project costs are financed through equity, while the remaining 70% are financed through debt.

Based on previous deals, Lebanon has faced significant challenges to fulfill its financial commitments. According to various agency ratings, Lebanon economic outlook was fluctuating between a stable and negative outlook starting from 2010 till date of the writing (Trading Economics, 2019a). Based on Lebanon's economic outlook and energy experts' opinion, we assume that the interest rate for natural gas pipelines will be around the LIBOR[17] rate for Lebanon plus 1%. Accordingly, we use a 9% interest rate in our calculations. We also consider that repayment of the loan will take place over 20 years. Accordingly, we calculate the Capital Recovery Factor (CRF), and account for the financing cost of the projects.

[17] Libor is a benchmark interest rate, and stands for London Interbank Offered Rate.

$$CRF = \frac{i + (1+i)^t}{(1+i)^t - 1} \quad (4)$$

- **The operational costs are calculated as follows:**

$$O = C\tau + \left(1 - (1-k)^{\frac{\delta}{\eta}}\right) NP \quad (5)$$

- τ is the share of the working costs from the capital cost, equivalent to 3.5% for a typical coastal pipeline, adapted from Sadeghi et al, work.
- k is the rate of natural gas utilized at the compressor station as fuel: where we assume it is equivalent to 0.4% for each 100 miles, adapted from Sadeghi et al, work.
- η is the distance separating two compressor stations: where we assume that the distance separating two compressor stations is 192 Km, adapted from Sadeghi et al, work.
- N is the volume of natural gas (m^3/year), a factor which is dependent on the volume of discovered reserves in Lebanon.
- P is the price of natural gas ($\$/m^3$), a parameter that we estimate according to the World Bank projections for natural gas price in Europe between 2020 and 2030.

Moreover, the cost an offshore pipeline is expected to be double the cost of an onshore pipeline (PPIAF, 2013). Therefore, we double the capital and operational costs for offshore sections considered in our study.

- **Feedstock costs, also known as the processing costs**: The processing cost will depend mainly on two variables: first is the quality of extracted gas, and second is the CAPEX of the processing facility. According to experts in the field, the cost of processing could range from $0.1/mmbtu to $4/mmbtu. According to Lebanon's Petroleum Activities Regulations (PAR), the Right Holder, i.e., the consortium awarded exploration and production license, "shall pay or deliver in kind Royalty without any cost at the delivery point specified in the Plan for Development and Production in the form of crude oil and other petroleum relative to the Right Holder's share of the petroleum extractive from all reservoirs covered by the relevant exploration and production agreement or an approved unitization agreement" (LPA, 2013). However, the delivery point of petroleum, and the quality of natural gas, is not expected to be defined until an exploration is made. Therefore, we use the same value used by Sadeghi, i.e. $1.25/mmbtu, as it falls within the previously suggested range.
- **Transit costs**: Since the suggested pipelines pass through many countries, a transit fee will be charged; where the fee is relative to the exported volume of natural gas and the distance crossed. According to Sadeghi, and based on the contracts in Europe in 2014, 7.1cents/m^3 were paid in each 1000 km as a transit fee in European countries.[18] However, Sadeghi's assumed transit fee in countries as Armenia,

[18] Equivalent to 0.000071 $/$m^3$/km

Turkey, and Iraq is lower, and equivalent to 1.7 cents/m^3 in each 1000 km.[19] In the case of Lebanon, the latter has already imported natural gas from Egypt through the Arab gas pipeline. In 2008, the agreed transportation charge across the AGP was $2/mmbtu. Given that the total distance between Arish, the starting point of the pipeline in Egypt, and Tripoli, the ending point of the pipeline in Lebanon is 1,045 km, the transit fee would be 6.8 $/m^3$ in each 1000 km. In this work, we assume that the transit fee that Lebanon has already paid to import natural gas is a good reflection about the transit fee which would be paid for export as well. Although Lebanon could negotiate better terms regarding transit fees, we use a value of 0.000068$/m^3$/km in our analysis.

Since the projects are expected to take place in the next decade or so, we refer to the World Bank's projection to estimate the price of natural gas between 2020 and 2030. The latest forecast of the price of natural gas in Europe is presented in table 7 (World Bank, 2018). Accordingly, the value we use in our economic calculations as a reference scenario 0.25$/m^3$, which falls within the range of the price forecast for the period 2020-2030. Given that the price forecast is highly sensitive to various market parameters and could deviate from the futuristic real price, we consider a 25% higher and lower price than the reference scenario, i.e. 0.20$/m^3$ and 0.30$/m^3$.

[19] Equivalent to 0.000017 $/m^3$/km

Table 7: World Bank Natural Gas Price forecast between 2020 and 2030.

Year	2020	2021	2022	2023	2024	2025	2030
Price ($/mmbtu)	7.0	7.1	7.2	7.3	7.4	7.5	8.0

Sabotage of natural gas pipelines is a common challenge when considering cross-border pipelines. Therefore, the economic feasibility of scenarios is investigated while taking into consideration a disruption rate for natural gas flow in the pipelines. We account for three disruption rate factors: 0%, 5%, and 10%. According, we consider that low risk scenarios are without disruption, while high risks scenarios face a 10% disruption rate.

CHAPTER VIII

ECONOMIC FEASIBILITY RESULTS

A project is considered economically feasible if the NPV is positive, and the IRR is higher than the discount rate. However, for large energy projects, an economically feasible project will not necessarily receive investors' attention. A project, such as cross-borders natural gas pipeline, will only be considered economically attractive project if the IRR of the latter is higher than 20%. With IRR ranging between 10% and 20% in the case of natural gas export pipelines from Lebanon, a project's attractiveness is low; however, it could be boosted by energy security considerations.

A. Case A: 20-inch pipeline

Results of case A, where we expect an availability of 5 tcf of natural gas, are presented in tables 11, 12, and 13 (see Appendix). Table 8 summarizes the main IRR values under low and high risk scenarios.

According to the IRR values, Pipelines 1 and 2 connecting Lebanon with Turkey onshore and offshore, respectively, are economically attractive under all suggested prices and disruption rates. Pipeline 3 connecting Lebanon to Iraq is economically feasible when the price of natural gas is 0.20$/m^3 with no disruption, and 0.25$/m^3 or higher at any disruption rate. The project is considered economically attractive when the price of natural gas is 0.25 $/m^3 or higher with disruption, and 0.30 $/m^3 with disruption.

Pipeline 4 connecting Lebanon to Egypt onshore, is economically feasible when the price of natural gas is 0.25$/m^3 or higher without disruption, and when the price of natural gas in 0.30 $/m^3, with disruption. Pipeline 5 connecting Lebanon to Egypt offshore is economically feasible when the price of natural gas is 0.25$/m^3 without disruption and 0.30 $/m^3 with disruption. Pipelines 4 and 5 become economically attractive when the price of natural gas is 0.30 $/m^3 without disruption.

Pipelines 6, 7 and 8, connecting Lebanon to Italy are not economically feasible under the suggested price range of natural gas.

Table 8: IRR (%) for suggested 20 inch pipelines under low and high risk scenarios.

	Low risk (0% disruption)			High risk (10% disruption)		
Price of ng ($/m^3) Pipeline	0.2	0.25	0.3	0.2	0.25	0.3
P1	62.8	91.2	119.54	51.5	76.9	102.41
P2	25.6	35.1	49.26	20.0	27.9	40.61
P3	11.2	23.6	36.17	6.2	17.2	28.43
P4	3	12.9	22.77	3.10	7.9	16.88
P5	5.6	14.5	23.33	<0	9.95	17.85
P6	<0	<0	<0	<0	<0	<0
P7	<0	<0	<0	<0	<0	<0
P8	<0	<0	<0	<0	<0	<0

Color Coding
IRR ≤10% (red)
10% <RR ≤ 15% (yellow)
15%<IRR≤20% (blue)
IRR >20% (green)

B. CASE B: 36-inch pipeline

Results of case B, where we expect an availability of 15 tcf of natural gas, are presented in tables 14, 15, and 16 (see Appendix). Table 9 summarizes the main IRR values under low and high risk scenarios.

According to the IRR values, Pipelines 1 and 2 connecting Lebanon with Turkey, onshore and offshore, respectively, pipeline 3 connecting Lebanon to Iraq, and pipeline 5 connecting Lebanon to Egypt offshore are economically attractive under all suggested prices and disruption rates.

Pipeline 4 connecting Lebanon to Egypt onshore, is economically feasible when the price of natural gas is 0.20$/m^3 at with disruption. The project is considered economically attractive when the price of natural gas is 0.20 $/m^3 or higher with no disruption of the flow of natural gas, and when the price of natural gas is 0.25$/m^3 or higher, no matter the disruption rate.

Pipelines 6, 7 and 8, connecting Lebanon to Italy are not economically feasible under the suggested price range of natural gas.

Table 9: IRR (%) for suggested 36 inch pipelines under low and high risks scenarios.

	LOW RISK (0%)			HIGH RISK (10%)		
Price of ng ($/m^3) Pipeline	0.2	0.25	0.3	0.2	0.25	0.3
P1	188.53	262.18	336.32	158.92	224.82	291.48
P2	84.14	121.50	158.86	68.96	102.52	136.09
P3	48.97	80.85	112.74	35.95	64.56	93.19

P4	28.18	53.45	78.77	17.9	40.45	63.16
P5	41.79	65.32	88.85	32.15	53.24	74.36
P6	<0	<0	3.98	<0	<0	<0
P7	<0	<0	0.73	<0	<0	<0
P8	<0	<0	<0	<0	<0	<0

Color Coding
IRR ≤10%
10% <RR ≤ 15%
15%<IRR≤20 %
IRR >20%

C. Case C:48-inch pipeline

Results of case C, where we expect an availability of 25 tcf of natural gas, are presented in tables 17, 18, and 19 (see Appendix). Table 10 summarizes the main IRR values under low and high risk scenarios.

According to the IRR values, Pipelines 1 and 2 connecting Lebanon with Turkey, onshore and offshore, respectively, pipeline 3 connecting Lebanon to Iraq, and pipeline 4 and 5 connecting Lebanon to Egypt, onshore and offshore, respectively, are economically attractive under all suggested prices and disruption rates.

Pipelines 6 connecting Lebanon to Italy via Turkey onshore is economically feasible when the price of natural gas is 0.30$/m^3 with no disruption. Yet Pipelines 7 and 8, connecting Lebanon to Italy, respectively, via Turkey offshore, and via Cyprus offshore are not economically feasible under the suggested price range of natural gas.

Table 10: IRR (%) for suggested 48 inch pipelines under low and high risk scenarios.

Price of ng ($/m^3) / Pipeline	LOW RISK (0%)			HIGH RISK (10%)		
	0.2	0.25	0.3	0.2	0.25	0.3
P1	300.33	415.56	530.80	253.86	357.48	461.09
P2	141.16	199.37	257.59	117.5	169.80	222.11
P3	82.09	130.63	179.17	62.24	105.82	149.41
P4	50.35	88.88	127.42	34.52	69.08	103.66
P5	74.44	110.84	147.25	59.49	92.16	124.82
P6	<0	<0	13.20	<0	<0	3.15
P7	<0	<0	9.73	<0	<0	0.51
P8	<0	<0	<0	<0	<0	<0

Color Coding
IRR ≤10%
10% <RR ≤ 15%
15%<IRR≤20%
IRR >20%

According to the presented results, the economic feasibility of any pipeline project, is foremost, related to the volumes of discoveries. In line with economies of scale, results indicates that the higher the discoveries and capacities of the pipelines, the higher the IRR of the project. In cases of modest discoveries of 5 tcf, pipelines to Turkey are always profitable, pipelines to Iraq and Egypt may also be considered under high price scenario. When discoveries increase to 15 tcf or higher, the outlook for pipelines to Iraq and Egypt becomes promising. However, pipelines to Italy are not justified on economic grounds in the studied scenarios.

CHAPTER XI

DISCUSSION OF DIFFERENT PIPELINES OPTIONS

To assess different pipeline options, we refer to the mixture of qualitative[20] and quantitative[21] analysis. Worthy to note, the Mediterranean is considered a deep sea, where the maximum recorded depth according to the World Atlas is 16,896 ft, equivalent to 5.15 Km. Accordingly, any offshore pipeline to be laid in the Mediterranean is expected to face several engineering challenges, considering such pipelines would be the be first of their kind in a deep maritime environment. Technical risks aside, we proceed and discuss the economic and political aspect of the proposed pipelines.

The proposed pipelines trajectories start in Lebanon and branch to either Syrian land, or Syrian EEZ, or Cypriot EEZ. According to article 79 of the UNCLOS, "all states are entitled to lay submarine cables and pipelines on the continental shelf, …subject to the consent of the coastal state". Therefore, selection of offshore pathways does not eliminate the need for cooperation with concerned states, and in this case, Cyprus and Syria as the first transit countries, to say the least.

Interestingly, the two major active political axis in the Middle East context are, first, the Pro-American, which is supported by Cyprus, and second, the Pro-Russian/Iranian,

[20] We surveyed relevant academic works published in academic journals, as well as non-academic readings related to development of East Mediterranean natural gas fields published on reputable websites. We referred to the latter to make sense of the national and international announcements, and to reflect the geopolitical mood for the Levant basin's development.
[21] Economic Analysis.

which is supported by Syria. Although political parties in Lebanon have different opinions about political debates in the Middle East, Lebanon as a country has announced the policy of non-interference. When it comes to selecting pipeline trajectories, the choice of transit countries could reflect a political alienation to either of the axis in the Middle East. Therefore, trajectory selection will not only depend on a thorough technical risk analysis of the pipelines, their economic attractiveness, and market opportunities, but also on political messages that such a trajectory could convey.

We can compare the selection of pipeline pathways to other politicized experiences in the energy sector in Lebanon. A few months ago, Iran offered to support Lebanon in solving the electricity crisis. Although Lebanon hasn't been able to reduce the gap between supply and demand, the Iranian offer has been dismissed. Similarly, Lebanon has also rejected American propositions related to the disputed maritime area in Southern Lebanon, and requested UN supervision for the negotiation process. Although Lebanon shared justifications for its choices, it is difficult to forgo the political dimension reflected in adopted energy policies. Following the same rationale, any of the proposed pipeline pathways might fail on political grounds, since each and every path could be associated with one of the two axis active in the region.

While Italy proves to be the most developed hub in the East Mediterranean in terms of high market liquidity, and availability of sufficient infrastructure as an entry point to European market, the pipeline project to Italy under the given assumption is economically profitable only when the discoveries and natural gas prices are high, while risks are low. In addition to the previous conditions, the only feasible pathway of the pipeline to Italy passes through Syria and Turkey, onshore. Other pathways starting offshore Syria and offshore Cyprus, are not economically justified in all scenarios.

In other words, the only feasible option connecting Lebanon to Italy is Onshore via Syria, and necessitates a low risk, high price environment. Even if such challenging conditions are met, the project remains financially unattractive. When it comes to the East Med pipeline, whether considered a pipeline of common interest and supported by the EU or not, it is evident that a 2000 km offshore pipeline designed to transport natural gas from a single East Mediterranean country is likely to face major challenges to attract funding given the suggested economic outcomes.

However, feeding such a large and costly pipelines connecting the East Mediterranean to Europe would require greater volumes of natural gas to become profitable. Large volumes could only be met if two or more countries cooperate, and embark on building a multinational pipeline. Russia, based on its role and influence in the Middle East, is well positioned to lead and shape natural gas exports from the East Mediterranean to Europe. As Russians have no foes in the region, they could play a significant role in aggregating natural gas from different fields, enhancing the economic profitability of projects targeting Europe, and maintain their monopoly of the market. Although Americans could block such an interference, neither of the powers have the ability to build its own pipe plans without the consent of the Mediterranean countries.

When looking at economically more promising regional pipelines connecting Lebanon to Turkey and Iraq, suggested pathways, whether onshore or offshore, pass through Syrian territories. Although onshore pipelines are cheaper, easier to build, monitor and maintain, the offshore pipelines option could be favored if the war, or even tension, continues for a long time on the northern border of Syria. In such circumstances, and for physical security considerations, an offshore pipeline could gain a security leverage. However, the flow of gas in the pipeline, whether onshore or offshore to Turkey is likely to be affected by the tense relationship between Syria and Turkey.

Given the geographically natural path of the suggested pipelines via Syria, the latter could also import some volumes of Lebanese natural gas if demand of natural gas increases in Syria, and no discoveries took place in its offshore territories, a highly unlikely scenario. However, the exclusivity of Syria as a transit state, in case Lebanon targets Turkey or Iraq as markets, lowers the bargaining power of Lebanon when negotiating conditions and transit prices. The monopoly of the path means that Lebanon would be left with no other options regarding transit countries. In absence of competitors, the conditions and transit price are likely to be higher than the norm.

Routes to Egypt, on the other hand, offer two alternative scenarios: one is offshore via Cyprus, and the other is onshore via Syria and Jordan. Even though the offshore path is slightly more beneficial in financial terms as compared with the onshore path, engineering challenges, safety, and environmental concerns could give leverage to the onshore path. If Egypt develops as an LNG hub in the future, and proves to be a reliable trade partner, the choice of the pathway is likely to be dictated by geopolitics as both pathways offer comparable economic benefits, while presenting common, but differentiated political risks.

In principle, geopolitical risk is the risk associated with terrorist acts, wars, and tension between states affecting the peaceful and normal course of international relations

(Caldara & Iacoviello, 2018). While geopolitical risk affects flow of capital, interest rate of projects, and appetite of investors, it is important to note that geopolitical risk is different than geopolitical actions. The hydrocarbon transportation industry is not free of risks, and it would be natural to face major risks when building cross-border pipelines. To overcome the geopolitical challenge, the industry resort to Political Risks guarantees (PRGs), which are designed to transfer risks, fully or partially to other parties, under defined losses caused by political events (OECD, 2019). Therefore, any pipeline option that Lebanon would choose is likely to be covered by PRG, before being implemented.

Although Lebanon is a Sovereign State, the choices selected by the country are largely affected by major political powers exercising their influence in the Middle East. While international concerns and desires of actors could block the development of a certain pipeline, their capabilities of building others are diminishing in the region. In a nutshell, the risk associated with different suggested options is significant, and would require thorough considerations of the future political realities by the time Lebanon declare official discoveries and export plans.

CHAPTER X

BRIEF OUTLOOK REGARDING THE LNG OPTION

Use of LNG as a mean to transport natural gas is less prone to terrorism and sabotage; therefore, LNG could reduce risk and risk premium as disruption of the flow of gas is expected to be lower than that of pipelines. In general, large gas production stream of natural gas (>500-600 mcf/d), available for 20 to 30 years, is the minimal necessary volume for a baseload liquefaction plant to be economical. In other words, 5 to 10 tcf of recoverable gas reserves are needed to supply these long haul projects (Mokhatab, Mak, Valappil, & Wood, 2014).

In comparing cost estimates of transportation alternatives, i.e. cross-border pipelines vs LNG exports, distance, the pathway of the pipeline, and the volume of gas transported affect the economics of transport. For a 48-inch pipeline, LNG would be more cost effective if the distance of a pipeline was greater than 5,000 km onshore, and 1,600 km offshore (PPIAF, 2013).

In the case of Lebanon and the targeted markets in this study, the length onshore suggested pipelines is smaller than 5000 km. Therefore, the LNG option does not make economic sense when selected pathways are onshore. LNG could only make economic sense if, first, discoveries were greater than 10 tcf, and, second, the country dismisses all regional and onshore gas pipelines, and targets Italy or other farther destinations as a market for LNG.

CHAPTER XI

CONCLUSION AND POLICY IMPLICATIONS

Lebanon is expected to face significant pipeline policy choices as the country explores different export pipelines options for its prospective natural gas resources. This work has explored various export options of natural gas via different pipeline routes, and framed the discussion of different proposed trajectories and destinations according to the economic competitiveness of the pipeline, as well as geopolitical considerations associated with selected pathways. Based on the results, we discussed risks of considering an onshore pipeline that passes through Syria and Cyprus. The reliability of a pipeline passing through Syria presents several challenges related to the physical and political security of the gas flow to market destinations in light of the war taking place in Syria, and the tense relationship between Syria and Turkey. On the other hand, a Cyprus offshore pathway presents several technical challenges related to the construction of a pipeline in deep water, as well as political challenges associated with the Turkish-Cypriot knot.

As noted in pipelines history, some cross-border gas trade projects are built; however, others languish. Natural gas pipelines connecting single East Mediterranean countries to Europe are better described as pipe dreams as flow of gas in offshore pipelines is not justified, on economic grounds at least. However, Russia, as a major political power, could increase chances of exporting natural gas from the East Mediterranean, and enhance the economic profitability of such project by aggregating gas from various countries.

Major risks will be faced when Lebanon takes a decision regarding the most profitable regional pathway, on economic and political grounds. Therefore, diplomatic efforts will be needed to configure adequate measures and procedures to ensure the security of gas flow in the pipeline to any market destination. If conflicts and uncertainties regarding behavior of transit states persist and prove to be significant, then Lebanon could be better off considering more expensive options such as developing plants to liquefy natural gas, if discoveries prove to be high enough. However, competitiveness of the LNG option in Lebanon will largely depend on the cost reduction of LNG facilities by the time Lebanon is ready to liquefy its natural gas.

APPENDIX

UNITS AND CONVERSION FACTORS

Tcf: trillion cubic feet

Bcm: billion cubic meter

Bcf: billion cubic feet

Mmbtu: million British thermal unit

M^3: meter cubic

Mtpa: million tons per annum

1 tcf = 28.3 bcm

1 bcm = 35.3 bcf

1 bcm = 35,700,000 mmbtu

1 trillion = 10^{12}

1 billion = 10^9

1 million = 10^6

1 thousand = 10^3

1 ft = 0.3048 m

TABLES

Table 11: Economic feasibility results for a 20 inch pipeline at a natural gas price of 0.20$/m3.

		Price of Natural Gas (0.20 $/m^3$)		
		Disruption rate		
		0%	5%	10%
P1	NPV (B$)	3.28	2.92	2.57
	IRR (%)	62.9	57.2	51.5
	Pb (yrs)	2	2	2
P2	NPV (B$)	1.94	1.59	1.24
	IRR (%)	25.6	22.8	20.0
	Pb (yrs)	4	4	6
P3	NPV (B$)	0.17	-0.18	-0.53
	IRR (%)	11.2	8.7	6.2
	Pb (yrs)	10	13	18
P4	NPV (B$)	-1.19	-1.54	-1.89
	IRR (%)	3	0.8	<0
	Pb (yrs)	23	29	>30
P5	NPV (B$)	-0.84		
	IRR (%)	5.6		
	Pb (yrs)	20		
P6	NPV (B$)	-10.00		
	IRR (%)	<0		
	Pb (yrs)	>30		
P7	NPV (B$)	-12.02		
	IRR (%)	<0		
	Pb (yrs)	>30		
P8	NPV (B$)	-18.06		
	IRR (%)	<0		
	Pb (yrs)	>30		

IRR ≤10%
10% <RR ≤ 15%
15%<IRR≤20%
IRR >20%

Table 12: Economic feasibility results for a 20 inch pipeline at a natural gas price of 0.25$/m3.

		Price of Natural Gas (0.25 $/m^3)		
		Disruption rate		
		0%	5%	10%
P1	NPV (B$)	5.00	4.56	4.13
	IRR (%)	91.2	84.1	76.9
	Pb (yrs)	1	2	2
P2	NPV (B$)	3.09	2.65	2.22
	IRR (%)	35.1	31.5	27.9
	Pb (yrs)	3	4	4
P3	NPV (B$)	1.88	1.44	1.00
	IRR (%)	23.6	20.4	17.2
	Pb (yrs)	5	5	5
P4	NPV (B$)	0.51	0.074	-0.36
	IRR (%)	12.9	10.4	7.9
	Pb (yrs)	8	11	14
P5	NPV (B$)	0.87	0.43	-0.009
	IRR (%)	14.5	12.2	9.95
	Pb (yrs)	8	8	11
P6	NPV (B$)	-8.36		

	IRR (%)	<0		
	Pb (yrs)	>30		
	NPV (B$)	-10.39		
	IRR (%)	<0		
P7	Pb (yrs)	>30		
	NPV (B$)	-16.47		
	IRR (%)	<0		
P8	Pb (yrs)	>30		

IRR ≤10%
10% <RR ≤ 15%
15%<IRR≤20%
IRR >20%

Table 13: Economic feasibility results for a 20 inch pipeline at a natural gas price of 0.30$/m3

		Price of Natural Gas (0.30 $/m^3)		
		Disruption rate		
		0%	5%	10%
	NPV (B$)	6.74	6.21	5.69
	IRR (%)	119.54	110.97	102.41
P1	Pb (yrs)	1	1	1
	NPV (B$)	4.81	4.29	3.76
	IRR (%)	49.26	44.94	40.61
P2	Pb (yrs)	3	3	3
	NPV (B$)	3.59	3.06	2.54
P3	IRR (%)	36.17	32.3	28.43

	Pb (yrs)	3	4	4
	NPV (B$)	2.21	1.69	1.16
	IRR (%)	22.77	19.71	16.88
P4	Pb (yrs)	5	6	7
	NPV (B$)	2.57	2.04	1.52
	IRR (%)	23.33	20.58	17.85
P5	Pb (yrs)	5	5	6
	NPV (B$)	-6.72		
	IRR (%)	<0		
P6	Pb (yrs)	>30		
	NPV (B$)	-8.76		
	IRR (%)	<0		
P7	Pb (yrs)	>30		
	NPV (B$)	-14.86		
	IRR (%)	<0		
P8	Pb (yrs)	>30		

IRR ≤10%
10% <RR ≤ 15%
15%<IRR≤20%
IRR >20%

Table 14: Economic feasibility results for a 36 inch pipeline and a natural gas price of 0.20$/m3.

		Price of Natural Gas (0.20 $/m^3$)		
		Disruption rate		
		0%	5%	10%
P1	NPV (B$)	13.53	12.40	11.26
	IRR (%)	188.05	173.10	158.92
	Pb (yrs)	1	1	1
P2	NPV (B$)	11.14	10.00	8.87
	IRR (%)	84.14	76.55	68.96
	Pb (yrs)	2	2	2
P3	NPV (B$)	6.85	5.72	4.58
	IRR (%)	48.97	42.45	35.95
	Pb (yrs)	3	3	3
P4	NPV (B$)	4.04	2.91	1.78
	IRR (%)	28.18	23.02	17.91
	Pb (yrs)	4	5	6
P5	NPV (B$)	7.76	6.42	5.29
	IRR (%)	41.79	36.97	32.15
	Pb (yrs)	3	3	4
P6	NPV (B$)	-13.76		

	IRR (%)	<0		
	Pb (yrs)	>30		
P7	NPV (B$)	-15.86		
	IRR (%)	<0		
	Pb (yrs)	>30		
P8	NPV (B$)	22.28		
	IRR (%)	<0		
	Pb (yrs)	>30		

IRR ≤10%
10% <RR ≤ 15%
15%<IRR≤20%
IRR >20%

Table 15: Economic feasibility results for a 36 inch pipeline and a natural gas price of 0.25$/m3.

		Price of Natural Gas (0.25 $/m^3)		
		Disruption rate		
		0%	5%	10%
P1	NPV (B$)	19.15	17.73	16.32
	IRR (%)	262.18	243.5	224.82
	Pb (yrs)	1	1	1
P2	NPV (B$)	16.71	15.30	13.87
	IRR (%)	121.50	112.01	102.52
	Pb (yrs)	1	1	1
P3	NPV (B$)	12.39	10.98	9.56

	IRR (%)	80.85	72.71	64.56
	Pb (yrs)	2	2	2
	NPV (B$)	9.56	8.14	6.72
	IRR (%)	53.45	46.95	40.45
P4	Pb (yrs)	2	3	3
	NPV (B$)	13.07	11.66	10.24
	IRR (%)	65.32	59.28	53.24
P5	Pb (yrs)	2	2	2
	NPV (B$)	-8.43		
	IRR (%)	<0		
P6	Pb (yrs)	>30		
	NPV (B$)	-10.56		
	IRR (%)	<0		
P7	Pb (yrs)	>30		
	NPV (B$)	-17.12		
	IRR (%)	<0		
P8	Pb (yrs)	>30		

IRR ≤10%
10% <RR ≤ 15%
15%<IRR≤20%
IRR >20%

Table 16: Economic feasibility results for a 36 inch pipeline at a natural gas price of 0.30$/$m^3$.

		Price of Natural Gas (0.30 $/m^3$)		
		Disruption rate		
		0%	5%	10%
P1	NPV (B$)	24.77	23.07	21.37
	IRR (%)	336.32	313.90	291.48
	Pb (yrs)	1	1	1
P2	NPV (B$)	22.29	20.59	18.89
	IRR (%)	158.86	147.47	136.09
	Pb (yrs)	1	1	1
P3	NPV (B$)	17.94	16.24	14.54
	IRR (%)	112.74	102.97	93.19
	Pb (yrs)	1	1	2
P4	NPV (B$)	15.07	13.37	11.67
	IRR (%)	78.77	70.97	63.16
	Pb (yrs)	2	2	2
P5	NPV (B$)	18.59	16.89	15.19
	IRR (%)	88.85	81.60	74.36
	Pb (yrs)	2	2	2
P6	NPV (B$)	-3.11		

	IRR (%)	3.98		
	Pb (yrs)	23		
	NPV (B$)	-5.27		
	IRR (%)	0.73		
P7	Pb (yrs)	29		
	NPV (B$)	-11.99		
	IRR (%)	<0		
P8	Pb (yrs)	>30		

IRR ≤10%
10% <RR ≤ 15%
15%<IRR≤20%
IRR >20%

Table 17: Economic feasibility results for a 48 inch pipeline and a natural gas price of 0.20$/m3.

		Price of Natural Gas (0.20 $/m^3)		
		Disruption rate		
		0%	5%	10%
	NPV (B$)	25.21	23.20	21.19
	IRR (%)	300.33	277.09	253.86
P1	Pb (yrs)	1	1	1
	NPV (B$)	22.42	20.40	18.39
	IRR (%)	141.16	129.33	117.5
P2	Pb (yrs)	1	1	1
P3	NPV (B$)	14.73	12.71	10.70

	IRR (%)	82.09	72.16	62.24
	Pb (yrs)	2	2	2
	NPV (B$)	10.38	8.36	6.35
	IRR (%)	50.35	42.43	34.52
P4	Pb (yrs)	2	3	3
	NPV (B$)	17.49	15.48	13.46
	IRR (%)	74.44	66.97	59.49
P5	Pb (yrs)	2	2	2
	NPV (B$)	-16.99		
	IRR (%)	<0		
P6	Pb (yrs)	>30		
	NPV (B$)	-19.01		
	IRR (%)	<0		
P7	Pb (yrs)	>30		
	NPV (B$)	-25.19		
	IRR (%)	<0		
P8	Pb (yrs)	>30		

IRR ≤10%
10% <RR ≤ 15%
15%<IRR≤20%
IRR >20%

Table 18: Economic feasibility results for a 48 inch pipeline and a natural gas price of 0.25$/m3.

		Price of Natural Gas (0.25 $/m^3$)		
		Disruption rate		
		0%	5%	10%
P1	NPV (B$)	35.21	32.69	30.17
	IRR (%)	415.56	386.52	357.48
	Pb (yrs)	1	1	1
P2	NPV (B$)	32.34	29.82	27.98
	IRR (%)	199.37	184.59	169.80
	Pb (yrs)	1	1	1
P3	NPV (B$)	24.59	22.07	19.55
	IRR (%)	130.63	118.23	105.82
	Pb (yrs)	1	1	1
P4	NPV (B$)	20.18	17.66	15.14
	IRR (%)	88.88	78.98	69.08
	Pb (yrs)	2	2	2
P5	NPV (B$)	27.30	24.79	22.27
	IRR (%)	110.84	101.50	92.16
	Pb (yrs)	1	1	2
P6	NPV (B$)	-7.93		
	IRR (%)	<0		

	Pb (yrs)	>30		
	NPV (B$)	-9.60		
	IRR (%)	<0		
P7	Pb (yrs)	>30		
	NPV (B$)	-16.02		
	IRR (%)	<0		
P8	Pb (yrs)	>30		

IRR ≤10%
10% <RR ≤ 15%
15%<IRR≤20%
IRR >20%

Table 19: Economic feasibility results for a 48 inch pipeline and a natural gas price of 0.30$/m3.

		Price of Natural Gas (0.30 $/m^3)		
		Disruption rate		
		0%	5%	10%
	NPV (B$)	45.20	42.18	39.16
	IRR (%)	530.80	495.95	461.09
P1	Pb (yrs)	1	1	1
	NPV (B$)	42.25	39.23	36.21
	IRR (%)	257.59	239.85	222.11
P2	Pb (yrs)	1	1	1
	NPV (B$)	34.44	31.42	28.40
P3	IRR (%)	179.17	164.29	149.41

	Pb (yrs)	1	1	1
P4	NPV (B$)	29.98	26.96	23.94
	IRR (%)	127.42	115.54	103.66
	Pb (yrs)	1	1	1
P5	NPV (B$)	37.12	34.10	31.07
	IRR (%)	147.25	136.04	124.82
	Pb (yrs)	1	1	1
P6	NPV (B$)	1.95	-1.07	-4.09
	IRR (%)	13.20	8.24	3.15
	Pb (yrs)	8	13	24
P7	NPV (B$)	0.19	-3.21	-6.23
	IRR (%)	9.73	5.27	0.51
	Pb (yrs)	11	21	29
P8	NPV (B$)	-12.89		
	IRR (%)	<0		
	Pb (yrs)	>30		

IRR ≤10%
10% <RR ≤ 15%
15%<IRR≤20%
IRR >20%

BIBLIOGRAPHY

Al Monitor. (2019). Is new energy league an alliance against Ankara? . *Presidency of the Republic of Turkey - Directorate of Communication.* Retrieved from https://www.iletisim.gov.tr/english/dis_basinda_turkiye/detay/is-new-energy-league-an-alliance-against-ankara#

Austvik, O. G., & Rzayeva, G. (2017). Turkey in the geopolitics of energy. *Energy Policy, 107*, 539-547. doi:https://doi.org/10.1016/j.enpol.2017.05.008

Azhari, T. (2019). Syria expects oil and gas production in 2023. *Lebanese Oil and Gas Initiative.* Retrieved from https://logi-lebanon.org/KeyIssue/Syria-expects-oil-and-gas-production-by-2023

BBC. (2011). New attack on Egypt gas pipeline to Israel and Jordan. *BBC News.* Retrieved from https://www.bbc.com/news/world-middle-east-15670301

BBC. (2014). Russia drops South Stream gas pipeline plan. *BBC News.* Retrieved from https://www.bbc.com/news/world-europe-30283571

Bilgin, M. (2009). Geopolitics of European natural gas demand: Supplies from Russia, Caspian and the Middle East. *Energy Policy, 37*(11), 4482-4492. doi:https://doi.org/10.1016/j.enpol.2009.05.070

Bilgin, M. (2011). Scenarios on European energy security: Outcomes of natural gas strategy in 2020. *Futures*, *43*(10), 1082-1090. doi:https://doi.org/10.1016/j.futures.2011.07.007

Blanchard, C. M. (2014). Lebanon: Background and U.S. Policy *Congressional Research Service.* Retrieved from https://fas.org/sgp/crs/mideast/R42816.pdf

Boersma, T. (2014). The Cancellation of South Stream is a Pyrrhic Victory, At Best. *Brookings.* Retrieved from https://www.brookings.edu/blog/up-front/2014/12/18/the-cancellation-of-south-stream-is-a-pyrrhic-victory-at-best/

Bolan, C. J. (2018). Russian and Iranian "Victory" in Syria: Does it Matters? *Foreign Policy Research Institute.* Retrieved from https://www.fpri.org/article/2018/12/russian-and-iranian-victory-in-syria-does-it-matter/

Boujikian, L. (2019). Development of natural gas in Lebanon : assessment of its impact on electric power generation. *American University of Beirut. Maroun Semaan Faculty of Engineering and Architecture. Department of Electrical and Computer Engineering.*

Bousso, R. (2018). Israel expects decision on East Med gas pipeline to Europe in 2019. *Reuters.* Retrieved from https://www.reuters.com/article/us-ceraweek-energy-israel/israel-expects-decision-on-east-med-gas-pipeline-to-europe-in-2019-idUSKCN1GK2OI

BP. (2018). BP Statistical Review of World Energy. *British Petroleum - 67th edition.* Retrieved from https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2018-full-report.pdf

BP. (2019). South Caucasus pipeline. *BP Azerbaijan.* Retrieved from https://www.bp.com/en_az/caspian/operationsprojects/pipelines/SCP.html

Caldara, D., & Iacoviello, M. (2018). Measuring Geopolitical Risk. *North Carolina State University.* Retrieved from https://www2.bc.edu/matteo-iacoviello/gpr_files/GPR_SLIDES.pdf

CLNG. (2019). History of LNG. Retrieved from https://lngfacts.org/about-lng/history-of-lng/

Dagher, L., & Ruble, I. (2011). Modeling Lebanon's electricity sector: Alternative scenarios and their implications. *Energy, 36*(7), 4315-4326. doi:https://doi.org/10.1016/j.energy.2011.04.010

Daily Sabah. (2018). Turkish Cypriot president: East-Med pipeline not a route to peace. Retrieved from https://www.dailysabah.com/energy/2018/05/10/turkish-cypriot-president-east-med-pipeline-not-a-route-to-peace

Debre, I. (2018). US ambassador pledges support for Mediterranean pipeline. *Business Insider*. Retrieved from https://www.businessinsider.com/ap-us-ambassador-pledges-support-for-mediterranean-pipeline-2018-12

Dezem, V. (2019). Germany Set to Draw More Russian Gas, Regardless of What Trump Says. *Bloomberg.* Retrieved from https://www.bloomberg.com/news/articles/2019-02-28/germany-natural-gas-demand-set-to-soar-as-coal-plants-close

Dudlák, T. (2018). After the sanctions: Policy challenges in transition to a new political economy of the Iranian oil and gas sectors. *Energy Policy*, *121*, 464-475. doi:https://doi.org/10.1016/j.enpol.2018.06.034

Dupont, P.-E. (2019). Lebanon's Southern Maritime Border Dispute: Legal Issues Challenges, and the Way Forward. *Issam Fares Institue for Public Policies and International Affairs.* Retrieved from https://www.aub.edu.lb/ifi/Documents/publications/working_papers/2018-2019/20190212_lebanon_southern_maritime_border_dispute.pdf

EC. (2018). EU imports of energy products - recent developments. *European Commission.* Retrieved from https://ec.europa.eu/eurostat/statistics-explained/pdfscache/46126.pdf

Edison. (2017). EastMed Pipeline. Retrieved from https://www.edison.it/en/eastmed-pipeline

EIA. (2011). Country Analysis Briefs: Syria. *Energy Information Administration.* Retrieved from https://www.eia.gov/beta/international/analysis_includes/countries_long/Syria/archive/pdf/syria_2011.pdf

EIA. (2014). Few transportation fuels surpass the energy densities of gasoline and diesel. *Energy Information Administration.* Retrieved from https://www.eia.gov/todayinenergy/detail.php?id=14451#

EIA. (2015). Natural gas pipelines under construction will move gas from Azerbaijan to southern Europe. *U.S. Energy Information Administration* Retrieved from https://www.eia.gov/todayinenergy/detail.php?id=23332

EIB. (2019). Trans Adriatic Pipeline (TAP) completes successful EUR 3.9 billion project financing. *European Investment Bank.* Retrieved from https://www.eib.org/en/infocentre/press/releases/all/2019/2019-004-trans-adriatic-pipeline-tap-completes-successful-eur-3-9-billion-project-financing.htm

El-Katiri, L., & El-Katiri, M. (2014). Regionalizing East Mediterranean Gas: Energy Security, Stability, and the U.S. Role. *Strategic Studies Institutes and U.S. Army War College Press.*

ENTSOG. (2017). The European Natural Gas Network 2017.

Erşen, E., & Çelikpala, M. (2019). Turkey and the changing energy geopolitics of Eurasia. *Energy Policy, 128,* 584-592.

Fattouh, B., & El-Katiri, L. (2015). Lebanon's Gas Trading Options. *The Lebanese Center for Policy Studies - LCPS.*

Ferrer, A. M., & Hamdan, H. A. (2016). Floating storage regasification unit (FSRU) the answer to locations with "No Gas" or "No Gas Infrastructure": a gas-to-power application. *POWER-GEN International 2016.*

Gas Strategies. (2019). EastMed pipeline: Modern dream in an ancient region. Retrieved from http://www.gasstrategies.com/blogs/eastmed-pipeline-modern-dream-ancient-region-0

Gazprom. (2019). TurkStream: Gas exports to Turkey and southern and southeastern Europe. *Gazprom.* Retrieved from http://www.gazprom.com/projects/turk-stream/

Ghafar, A. A. (2015). Egypt's new gas discovery: Opportunities and challenges. *Brookings, OP-ED.* Retrieved from https://www.brookings.edu/opinions/egypts-new-gas-discovery-opportunities-and-challenges/

Global, Y. (2018). Egypt Aims For Natural Gas Dominance In The Mediterranean. *Oil Price.* Retrieved from https://oilprice.com/Energy/Energy-General/Egypt-Aims-For-Natural-Gas-Dominance-In-The-Mediterranean.html

Grandchamps, C. (2019). Projet du gazoduc EastMed reliant Israël à l'Europe : quel impact sur le Liban ? *L'Orient Le Jour*. Retrieved from https://www.lorientlejour.com/article/1162412/projet-du-gazoduc-eastmed-reliant-israel-a-leurope-quel-impact-sur-le-liban-.html

Guo, B., Song, S., Ghalambor, A., & Chacko, J. (2005). *Offshore pipelines*: Elsevier.

Hamdan, H. A., & Khoury, R. (2015). *LNG supply for Lebanon's power sector in light of the pending offshore gas discoveries and the world's falling oil prices.* Paper presented at the 2015 12th International Conference on the European Energy Market (EEM).

Harsem, Ø., & Harald Claes, D. (2013). The interdependence of European–Russian energy relations. *Energy Policy, 59*, 784-791. doi:https://doi.org/10.1016/j.enpol.2013.04.035

Heather, P. (2015). The evolution of European traded gas hubs. *Oxford Institute for Energy Studies* Retrieved from https://www.oxfordenergy.org/wpcms/wp-content/uploads/2016/02/NG-104.pdf

Henderson, S. (2017). Israel's Gas Disappointment. *The Washington Institute for Near East Policy*. Retrieved from https://www.washingtoninstitute.org/policy-analysis/view/israels-gas-disappointment

Hulshof, D., van der Maat, J.-P., & Mulder, M. (2016). Market fundamentals, competition and natural-gas prices. *Energy Policy, 94*, 480-491. doi:https://doi.org/10.1016/j.enpol.2015.12.016

IEA. (2018). World Energy Outlook 2018. *International Energy Agency*. Retrieved from https://www.iea.org/weo2018/

IEA. (2019). Gas 2018: Analysis and Forcasts to 2023. *International Energy Agency*. Retrieved from https://www.iea.org/gas2018/

ILF. (2016). Cost Benefit Analysis for the Use of Natural Gas and Low Carbon Fuels - Final Report. *UNDP - SODEL.* Retrieved from http://procurement-notices.undp.org/view_file.cfm?doc_id=107786

Jordan News Agency. (2019). Jordan, Egypt sign gas supply agreement for 2019. *Public News.* Retrieved from http://petra.gov.jo/Include/InnerPage.jsp?ID=12397&lang=en&name=en_news

JT. (2019a). Egypt to supply Kingdom with half of its gas needs this year. *Jordan Times.* Retrieved from http://jordantimes.com/news/local/egypt-supply-kingdom-half-its-gas-needs-year

JT. (2019b). Egyptian gas supply to Jordan officially resumed. *The Jordan Times.* Retrieved from http://www.jordantimes.com/news/local/egyptian-gas-supply-jordan-officially-resumed

Khodadad, N. L. (2014). Financing Cross-Border Pipelines: International Meeting of Experts on Reliable and Stable Transit of Energy for Sustainable Development. *Vinson & Elkins LLP.* Retrieved from https://energycharter.org/fileadmin/DocumentsMedia/Events/IME_Ashgabat_2014_S3_Khodadad.pdf

Khraiche, D. (2017). Total, Eni, Novatek Win Lebanon's First Offshore Licenses. *Bloomberg, Markets.* Retrieved from https://www.bloomberg.com/news/articles/2017-12-14/total-eni-novatek-win-lebanon-s-first-offshore-energy-licenses

Koduvayur, V., & Everett, G. (2019). Russia's Gas Web Ensnares Europe. *Foreign Policy.* Retrieved from https://foreignpolicy.com/2019/04/17/russias-gas-web-ensnares-europe/

Koukakis, N. (2019). ExxonMobil makes biggest natural gas discovery in two years off the coast of Cyprus. *CNBC.* Retrieved from https://www.cnbc.com/2019/02/28/exxonmobil-makes-big-natural-gas-discovery-off-the-coast-of-cyprus.html

Kozhanov, N. (2015). What's at stake for Russia in Syria? *BBC News.* Retrieved from https://www.bbc.com/news/world-middle-east-34290965

Lebanese University. (1955). مقاطعة اسرائيل. *Legal Informatics Center.* Retrieved from http://www.legallaw.ul.edu.lb/LawView.aspx?opt=view&LawID=257636

Lebanon Gas and Oil. (2019). Lebanese Energy Officials in Egypt After the East-Med Forum Establishment. Retrieved from http://www.lebanongasandoil.com/index.php/news-details/170

Lebanon Gas News. (2018). U.S. proposal on maritime border of Israel's claims.

Lohmann, S., & Westphal, K. (2019). US-Russia Policy Hits European Energy Supply. *German Institute for International and Security Affairs.* Retrieved from https://www.swp-berlin.org/10.18449/2019C06/

Loskot-Strachota, A., & Lasocki, J. (2013). End of Nabucco – end of Southern Gas Corridor? *Energy Post.* Retrieved from https://energypost.eu/end-of-nabucco-end-of-southern-gas-corridor/

LPA. (2013). The Petroleum Activities Regulations. Retrieved from https://lpa.gov.lb/regulations.php

LPA. (2017). First Offshore Licensing Round Results. *Lebanese Petroleum Administration.* Retrieved from https://www.lpa.gov.lb/first%20licensing%20round%20results.php

LPA. (2019). Second Licensing Round. *Lebanese Petroleum Administration.* Retrieved from https://lpa.gov.lb/secondlicensinground.php

Magdy, M. (2019). Talks Underway to Build New Gas Pipeline to Egypt, Israel Says. *Bloomberg.* Retrieved from https://www.bloomberg.com/news/articles/2019-01-15/talks-underway-to-build-new-gas-pipeline-to-egypt-israel-says

Marcel, V. (2013). Prospects for good governance in Lebanon's nascent petroleum sector. *Energy Strategy Reviews, 2*(1), 122-124. doi:https://doi.org/10.1016/j.esr.2013.03.001

Marketos, T. N. (2018). Eastern Mediterranean Energy Geostrategy on Proposed Gas Export Routes. *Fondation pour la Recherche Strategique.* Retrieved from https://www.frstrategie.org/web/documents/publications/notes/2018/201811.pdf

Mckinsey. (2018). Global Gas and LNG Outlook to 2035. *Energy Insights.* Retrieved from https://www.mckinsey.com/solutions/energy-insights/global-gas-lng-outlook-to-2035/~/media/3C7FB7DF5E4A47E393AF0CDB080FAD08.ashx

Melikoglu, M. (2013). Vision 2023: Forecasting Turkey's natural gas demand between 2013 and 2030. *Renewable and Sustainable Energy Reviews, 22*, 393-400. doi:https://doi.org/10.1016/j.rser.2013.01.048

Ministry of Petroleum. (2010). Strategic Projects: Arab Gas Pipeline. *Arab Republic of Egypt: Ministry of Petroleum.* Retrieved from http://www.petroleum.gov.eg/en/ProjectsandActivities/StrategicProjects/Pages/GasPipeline.aspx

Miriello, C., & Polo, M. (2015). The development of gas hubs in Europe. *Energy Policy, 84*, 177-190. doi:https://doi.org/10.1016/j.enpol.2015.05.003

Mitchell, J. V., Morita, K., Selley, N., & Stern, J. (2001). *The new economy of oil: Impacts on business, geopolitics and society*: Earthscan London.

Mitrova, T., Boersma, T., & Galkina, A. (2016). Some future scenarios of Russian natural gas in Europe. *Energy Strategy Reviews, 11-12*, 19-28. doi:https://doi.org/10.1016/j.esr.2016.06.001

Mohammadi, M., Noorollahi, Y., Mohammadi-ivatloo, B., Hosseinzadeh, M., Yousefi, H., & Khorasani, S. T. (2018). Optimal management of energy hubs and smart energy hubs – A review. *Renewable and Sustainable Energy Reviews, 89*, 33-50. doi:https://doi.org/10.1016/j.rser.2018.02.035

Mokhatab, S., Mak, J. Y., Valappil, J. V., & Wood, D. A. (2014). Chapter 3 - Natural Gas Liquefaction *Handbook of Liquefied Natural Gas* (pp. 147-183). Boston: Gulf Professional Publishing.

Natgas. (2013). History of natural gas. *NaturalGas Org.* Retrieved from http://naturalgas.org/overview/history/

NGW. (2013). Some reasons to materialize Iran, Iraq, and Syria's gas pipeline. *Natural Gas World.*

NGW. (2014). The Leviathan-Turkey pipeline scenario. *Natural Gas World.*

OECD. (2019). Political Risk Insurance and Guarantees. *Organization for Economic Cooperation and Development.* Retrieved from http://rmid-oecd.asean.org/database/political-risks/political-risk-insurance-guarantees-2/

Osseiran, K. (2015). Energy Security: The Lebanese Case. *CEDRO-UNDP.* Retrieved from http://www.cedro-undp.org/content/uploads/Publication/141229111001882~Energysecurity-thelebanesecaser2.pdf

Ozturk, M., Yuksel, Y. E., & Ozek, N. (2011). A Bridge between East and West: Turkey's natural gas policy. *Renewable and Sustainable Energy Reviews, 15*(9), 4286-4294. doi:https://doi.org/10.1016/j.rser.2011.07.122

Petersen, A. (2009). Nabucco Pipeline: Over Before It Started? *Atlantic Council.* Retrieved from https://www.atlanticcouncil.org/blogs/new-atlanticist/nabucco-pipeline-over-before-it-started

Pierini, M. (2019). Russia's Gas Strategy Gets Help From Turkey. *Carnegie Europe.* Retrieved from https://carnegieeurope.eu/strategiceurope/77855

PPIAF. (2013). Regional Gas Trade Projects in Arab Countries. *Public-Private Infrastructure Advisory Facilities and the World Bank.*

Reuters. (2011). Iran to ink gas contact with Syria, Iraq. *Energy & Oil News - Reuters.* Retrieved from https://af.reuters.com/article/energyOilNews/idAFL6E7IO07C20110724

Reuters. (2019). Eastern Mediterranean countries to form regional gas market. Retrieved from https://www.reuters.com/article/us-egypt-energy-gas/eastern-mediterranean-countries-to-form-regional-gas-market-idUSKCN1P81FG

Rose, S., & Brown, J. (2019). Russia looks to energy for a foothold in Lebanon. *The National.* Retrieved from https://www.thenational.ae/world/mena/russia-looks-to-energy-for-a-foothold-in-lebanon-1.834405

Ruble, I. (2017). European Union energy supply security: The benefits of natural gas imports from the Eastern Mediterranean. *Energy Policy*, *105*, 341-353.

Rzayeva, G. (2018). Gas Supply Changes in Turkey. *The Oxford Institute for Energy Studies.* Retrieved from https://www.oxfordenergy.org/publications/gas-supply-changes-turkey/

S&P Global. (2018). Cyprus, Egypt commit to new gas pipeline with intergovernmental deal. *Commodity, Natural Gas.* Retrieved from https://www.spglobal.com/platts/en/market-insights/latest-news/natural-gas/092018-cyprus-egypt-commit-to-new-gas-pipeline-with-intergovernmental-deal

Sadeghi, Z., Horry, H. R., & Khazaee, S. (2017). An economic evaluation of Iranian natural gas export to Europe through proposed pipelines. *Energy Strategy Reviews*, *18*, 1-17.

Saif, I., Atallah, S., Berro, A., & Khadouri, W. (2011). Gas in the Levant Basin: Another Source of Regional Conflict? *Carnegie Middle East Center.* Retrieved from http://carnegie-mec.org/2011/10/20/gas-in-levant-basin-another-source-of-regional-conflict-event-3403

Shadbolt, P., & Macguire, E. (2012). Lebanon: Country profile. *CNN*. Retrieved from https://edition.cnn.com/2012/08/10/world/meast/lebanon-country-profile/index.html

Shi, X. (2016). Development of Europe's gas hubs: Implications for East Asia. *Natural Gas Industry B, 3*(4), 357-366. doi:https://doi.org/10.1016/j.ngib.2016.11.001

Shi, X., & Variam, H. M. P. (2018). Key elements for functioning gas hubs: A case study of East Asia. *Natural Gas Industry B, 5*(2), 167-176. doi:https://doi.org/10.1016/j.ngib.2018.03.001

Siddig, K., & Grethe, H. (2014). No more gas from Egypt? Modeling offshore discoveries and import uncertainty of natural gas in Israel. *Applied Energy, 136*, 312-324. doi:https://doi.org/10.1016/j.apenergy.2014.09.019

Siddig, K., Grethe, H., & Abdelwahab, N. (2016). The natural gas sector in post-revolution Egypt. *Journal of Policy Modeling, 38*(5), 941-953. doi:https://doi.org/10.1016/j.jpolmod.2016.03.009

Skalamera, M. (2016). Invisible but not indivisible: Russia, the European Union, and the importance of "Hidden Governance". *Energy Research & Social Science, 12*, 27-49. doi:https://doi.org/10.1016/j.erss.2015.11.009

Skalamera, M. (2018). Revisiting the Nabucco Debacle: Myths and Realities. *Problems of Post-Communism, 65*(1), 18-36.

Smith, H. (2019). Huge gas discovery off Cyprus could boost EU energy security. *The Guardian*. Retrieved from https://www.theguardian.com/world/2019/feb/28/huge-gas-discovery-off-cyprus-could-boost-eu-energy-security

Souleimanov, E. A., & Dzutsati, V. (2018). Russia's Syria War: A Strategic Trap? *Middle East Policy Council.* Retrieved from https://www.mepc.org/journal/russias-syria-war-strategic-trap

Statista. (2018). Leading natural gas producing countries worldwide 2017. Retrieved from https://www.statista.com/statistics/264771/top-countries-based-on-natural-gas-production/

Stern, J., & Rogers, H. (2011). The Transition to Hub-Based Gas Pricing in Continental Europe. *Oxford Institute for Energy Studies.* Retrieved from https://www.oxfordenergy.org/wpcms/wp-content/uploads/2011/03/NG49.pdf

Stewart, M. (2016). 11 - Pipeline systems. In M. Stewart (Ed.), *Surface Production Operations* (pp. 813-884). Boston: Gulf Professional Publishing.

Sukkarieh, M. (2018a). Aphrodite's blues: Cyprus and Israel diverge over shared gas reservoir. *Executive Magazine.* Retrieved from http://www.executive-magazine.com/economics-policy/aphrodites-blues

Sukkarieh, M. (2018b). Lebanon's second licensing round: Lessons learned and the case for stability. *Executive Magazine.* Retrieved from http://www.executive-magazine.com/economics-policy/lebanons-second-licensing-round

Sukkarieh, M. (2019). The Eastern Mediterranean Gas Forum. *Executive Magazine.* Retrieved from http://www.executive-magazine.com/economics-policy/the-eastern-mediterranean-gas-forum

SW. (2019). Arab Gas Pipeline. *Source Watch.* Retrieved from https://www.sourcewatch.org/index.php/Arab_Gas_Pipeline

Tagliapietra, S. (2014). Turkey as a Regional Natural Gas Hub: Myth or Reality? *Review of Environment, Energy and Economics (Re3), Forthcoming*.

Tagliapietra, S. (2015). Turkey and the regional natural gas geopolitics. The "Hub Vision" in light of the future prospects of the southern gas corridor. *Quaderns de la Mediterrània*(22).

Tagliapietra, S. (2017a). Is the EastMed gas pipeline just another EU pipe dream? Retrieved from http://bruegel.org/2017/05/is-the-eastmed-gas-pipeline-just-another-eu-pipe-dream/

Tagliapietra, S. (2017b). Is the EastMed gas pipeline just another EU pipe dream? *Bruegel.* Retrieved from http://bruegel.org/2017/05/is-the-eastmed-gas-pipeline-just-another-eu-pipe-dream/

Tayseer, M., & Benmeleh, Y. (2018). Jordan Pipeline for Israeli Gas Set for Completion by End of 2019. *Bloomberg.* Retrieved from https://www.bloomberg.com/news/articles/2018-07-04/jordan-pipeline-for-israeli-gas-set-for-completion-by-end-2019

TDS. (2019a). Lebanon will mark maritime border with UN supervision: Berri. *The Daily Star*. Retrieved from http://www.dailystar.com.lb/News/Lebanon-News/2019/Apr-23/481719-lebanon-agrees-to-mark-maritime-border-using-blue-line-mechanism-berri.ashx

TDS. (2019b). Satterfield in Beirut for border dispute talks. *The Daily Star*. Retrieved from http://www.dailystar.com.lb/News/Lebanon-News/2019/May-15/483191-satterfield-in-beirut-for-border-dispute-talks.ashx

The Daily Star. (2019a). Bassil reinforces Lebanese sovereignty ahead of pipeline project.

The Daily Star. (2019b). Hariri calls for strict austerity measures to save economy. *The Daily Star*. Retrieved from http://www.dailystar.com.lb/News/Lebanon-News/2019/Apr-17/481381-hariri-calls-for-strict-austerity-measures-to-save-economy.ashx

The Daily Star. (2019c). Russian oil company to operate Tripoli's oil storage. *The Daily Star*. Retrieved from http://www.dailystar.com.lb/News/Lebanon-News/2019/Jan-25/474986-russian-oil-company-to-operate-tripoli-oil-storages.ashx

TJT. (2019a). Hundreds gather downtown to protest Jordan-Israel gas deal. *The Jordan Times*. Retrieved from http://www.jordantimes.com/news/local/hundreds-gather-downtown-protest-jordan-israel-gas-deal

TJT. (2019b). MPs demand scrapping Israeli gas deal 'at any cost'. *The Jordan Times*. Retrieved from http://www.jordantimes.com/news/local/mps-demand-scrapping-israeli-gas-deal-%E2%80%98-any-cost%E2%80%99

Trading Economics. (2019a). Lebanon - Credit Rating. Retrieved from https://tradingeconomics.com/lebanon/rating

Trading Economics. (2019b). Lebanon Interest Rate.

Tsafos, N. (2019). Can the East Med Pipeline Work? *Center for Strategic and International Studies*. Retrieved from https://www.csis.org/analysis/can-east-med-pipeline-work

USDT. (2019). Iran Sanctions. *US Department of the Treasury*. Retrieved from https://www.treasury.gov/resource-center/sanctions/programs/pages/iran.aspx

USGS. (2010). Assessment of Undiscovered Oil and Gas Resources of the Levant Basin Province, Eastern Mediterranean. *U.S. Geological Survey*. Retrieved from https://pubs.usgs.gov/fs/2010/3014/pdf/FS10-3014.pdf

Vatansever, A. (2017). Is Russia building too many pipelines? Explaining Russia's oil and gas export strategy. *Energy Policy, 108*, 1-11. doi:https://doi.org/10.1016/j.enpol.2017.05.038

Verocy. (2018). East Med Gas Pipeline is a Missed Chance for Regional Cooperation and Security. Retrieved from https://verocy.com/saudi-strategic-upd/east-med-gas-pipeline-is-missed-chance-for-regional-cooperation-and-security/

World Bank. (2004). Republic of Lebanon : Hydrocarbon Strategy Study. Retrieved from https://openknowledge.worldbank.org/handle/10986/15684

World Bank. (2016). Trans-Anatolian Natural Gas Pipeline Project. *World Bank Group*. Retrieved from http://projects.worldbank.org/P157416?lang=en

World Bank. (2018). World Bank Commodities Price Forecast (nominal US dollars). Retrieved from http://pubdocs.worldbank.org/en/823461540394173663/CMO-October-2018-Forecasts.pdf

Yafimava, K. (2018). Building New Gas Transportation Infrastructure in the EU–what are the rules of the game? Retrieved from https://www.oxfordenergy.org/wpcms/wp-content/uploads/2018/07/Building-New-Gas-Transportation-Infrastructure-in-the-EU-what-are-the-rules-of-the-game.pdf

Zein, T. E. (2004). Natural gas pipeline to be finished by June. *The Daily Star*. Retrieved from http://www.dailystar.com.lb/Business/Lebanon/2004/Apr-02/410-natural-gas-pipeline-to-be-finished-by-june.ashx

Zhang, D., Wang, T., Shi, X., & Liu, J. (2018). Is hub-based pricing a better choice than oil indexation for natural gas? Evidence from a multiple bubble test. *Energy Economics*, *76*, 495-503. doi:https://doi.org/10.1016/j.eneco.2018.11.001