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Developing Gas Trading Hub in Eastern Mediterranean Region: Requirements, Challenges and, Changes (*)

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Abstract

The paper aims to analyze the geographical and market requirements for selecting the appropriate location and site for the regional gas trade hub, determine the international and regional challenges facing the establishment of a regional gas trading hub in the Eastern Mediterranean, and predict the changes that will occur when the regional gas trading hub in Egypt emerges.

The study is based on both: Global Commodity Chains GCCs methodology, which examines the role of local, regional, and global connections in the emergence and development of Gas Trade Hubs, and TOPSIS (Technique for Order Preference by Similarity to Ideal Solution).

The study concluds by outlining a set of geographical and market requirements that must be met to develop a gas trade hub in the Eastern Mediterranean. The investigation reveals that Italy, Egypt, and Turkey are the most ideal locations for the concentration of the gas hub, respectively. The research also shows that Idku, Damietta, and Port Said are the most important sites in Egypt.

The study also concludes with the following results: there are economic, political, environmental, and technological obstacles in the development of gas trade hubs, and gas production and trade in the eastern Mediterranean, which will result in significant changes in gas producing regions, infrastructure, networks, markets, and regional development.

تطوير مركز لتجارة الغاز في اقليم شرق المتوسط المتطلبات والتحديات والتغيرات

الدكتور/ جمال محمد عطية مصطفى

أستاذ مساعد– قسم جغرافيا– كلية الدراسات الافريقية العليا– جامعة القاهرة

تهدف الدراسة الي تحليل المتطلبات الجغرافية والسوقية لاختيار الموقع والموضع المناسبين لمركز تجارة الغاز الإقليمي. تحديد التحديات الدولية والإقليمية التي تواجه إنشاء

مركز إقليمي لتجارة الغاز في شرق المتوسط. التنبؤ بالتغيرات المكانية التي ستحدث عندما يظهر المركز الإقليمي لتجارة الغاز في مصر.

واستندت الدراسة إلى منهجية سلاسل السلع العالمية التي تدرس دور الروابط والإقليمية والعالمية في ظهور وتطوير مراكز تجارةالغاز. واعتمادا علي تحليلات تقنيات الترتيب الافضل حسب تشابه الحل الامثل TOPSIS.

وانتهت الدراسة بإيجاز الي مجموعة من المتطلبات الجغرافية والسوقية التي يجب تلبيتها لتطوير مركز لتجارة الغاز في شرق البحر الأبيض المتوسط. وكشف التحليل أن دول إيطاليا ومصر وتركيا هي المواقع الأكثر مثالية لتركيز محور الغاز، على التوالي. كما كشفت تحليلات الأوزان أن "إدكو" و"دمياط" و"بورسعيد" هي أهم المواضع في مصر.

وخلصت الدراسة إلى وجود عقبات اقتصادية وسياسية وبيئية وتكنولوجية أمام تطوير مركز تجارة الغاز، وأن إنتاج الغاز وتجارة الغاز في شرق البحر المتوسط سيؤدي إلى تغييرات مكانية كبيرة في المناطق المنتجة للغاز والبنية التحتية والشبكات والأسواق والتنميةالإقليمية

1. Introduction

Egypt has gas supplies that make it at least self-sufficient if it can tackle the demand issue and has a strong infrastructure that allows it to become a hub for liquefied natural gas (LNG) trade in the Eastern Mediterranean region if it can boost supply sources. If successful, it will therefore have a major effect on the balancing of European and global gas markets, after discovering of the giant Zohr field and several new discoveries (Ouki, 2018, p.1).

- **Study aims**

The aims of study are analyzing the geographical and market requirements for select the appropriate location and site for the regional gas trade hub, determining the international and regional challenges face the establishment of a regional gas trading hub in the Eastern Mediterranean and, predicting the changes that will occur when the regional gas trading hub in Egypt emerges.

- **Hypotheses**
- Strong gas infrastructure, a free trade and economic system are needed to create a regional gas trading hub.

- The establishment of a regional gas trading hub faces many challenges by the actors in the global gas trading markets.
- The development of a regional gas trade hub is followed by changes in the spatial structure surrounding it.
- **Study notion**

Using **T**echnique for **O**rder **P**reference by **S**imilarity to **I**deal **S**olution (TOPSIS) technique and weights &competitiveness analysis to identify the most suitable location for the Eastern Mediterranean Regional Gas Trade Hub, analyze its challenges, and observe the anticipated spatial changes.

Previous studies

- Xunpeng, S. & Varimax, H. (2018 A) About Key elements for functioning gas hubs: A case study of East Asia. This paper clarifies different concepts relevant to gas trading hubs and presents an innovative framework for the creation of gas hubs with key elements.
- Ouki.M. (2018B) Egypt - a return to a balanced gas market? This paper indicates that Egypt holds a key role in the gas production of the East Mediterranean. It aims to become a regional gas export hub to monetize its own natural gas wealth and to re-export gas from current and future gas supply sources.
- Bridge, G.& Bradshaw, M. (2017) Making a Global Gas Market: Territoriality and Production Networks in Liquefied Natural Gas. A Global Production Network (GPN) methodology is used in this article to analyze the evolutionary dynamics and role of the liquefied natural gas (LNG) sector in the developing global natural gas market. The article offers the first systematic analysis of the globalization of the LNG market and its effect on the global gas sector within the economic geography.
- Heather, P. (2015) the evolution of European traded gas hubs. This article comprises the characteristics and requirements of different gas hub models and the 'path to maturity' an in-depth analysis of the European gas hubs, using both quantitative and qualitative frameworks.
- Baik, R. (2015) Natural Resources Investment of Oil and Gas and Regional Development Impact on Community

Empowerment. This study was performed in the Bekasi district of West Java, Indonesia, with the goal of analyzing the management of upstream oil and gas industry activities (exploration and production) and their impact on improving infrastructure quality, ensuring equal benefits for corporations, local governments, and society, and CSR programs that affect community empowerment.

- Xiaoguang.T. Jiong, Z. and Bo. F. (2014) Strategic analysis on establishing a natural gas trading hub in China. SWOT analysis (strength, weakness, Threat, and opportunity) is the basis of this paper .The study of the marketing mechanism and strategies were presented to assist China in making the right decision and seeking a periodic strategic route for natural gas.
- Weijermars, R (2010). Value chain analysis of the natural gas industry- Lessons from the US regulatory success and opportunities for Europe. This study explains in a systemic manner the physical and financial value chains of the US natural gas sector in a concise way, a regulatory decision-making framework regulates and interconnects the value chains of the natural gas industry.

2. Methodology, Techniques, Data source and theoretical framework

The study was based on Global Commodity Chains GCCs methodology that examines the role of Local, Regional and Global Connections in the emergence and development of Gas Trade Hubs and the integration of various Regions and showing how we create, distribute, and sell the variety of products we consume daily (MacKinnon &cumbers, 2019, p.14).

TOPSIS (**T**echnique for **O**rder **P**reference by **S**imilarity to **I**deal **S**olution) can be expressed in a series of steps:

- Construct the normalized decision matrix: values square, square root, and square root/ original value.
- Construct the weighted normalized decision matrix 0-1. weight value x normalized matrix.
- Finding and Calculating a positive and negative ideal solutions,

$$si+= \left(\sqrt{(a-s)^2}\right) + \sqrt{(b-s)^2} + \sqrt{(c-s)^2}$$

$$si-=\left(\sqrt{(a-s)^2}\right)+\sqrt{(b-s)^2}+\sqrt{(c-s)^2}$$

- Calculate the relative closeness to the Ideal Solution.

$$\text{ci}=\frac{si^-}{si^-+si+}$$

- Rank the preference order (Balioti, V. et al,2018, pp.2-3)
- Market concentration index and churn rate

i. Statistical sources

1- Ministry of Petroleum, Egyptian Natural Gas Company (GASCO), Annual Reports, Cairo, 2020.
2- Ministry of Petroleum, Egyptian Natural Gas Holding Company (EGAS), Annual Reports, Cairo. multiple editions (2017-2018), (2018-2019).
3- Gas Market Regulatory Authority, The Periodic Newsletter of the Egyptian and international natural gas markets, 1st Edition Jan 2020- 23th Edition July 2021.
4- Eni, World Gas and Renewable Reviews, Roma, multiple issues, Vol.2. 2018, 2019, 2020.
5- BP, Statistical Review of World Energy, 2019.
6- International Gas Union, (2019), world LNG Report, Kogas, AGA Seoul.
7- Mediterranean Energy Regulators, (2018), Gas infrastructure map of Mediterranean Region, Working Group in Gas, Final Report, Milan.

ii. Documentary sources

8- Memorandum of understanding on a strategic partnership on Energy between the European Union and the Arab Republic of Egypt 2018 – 2022.
9- Gas Market Regulatory Authority, Law No. 196 Regulating Gas Market Activities, 2017, Official Gazette No. 30, Parliament, Cairo, August 2017.
10- European parliament, (2017), Energy: a shaping factor for regional stability in the Eastern Mediterranean, directorate-general for external policies, Belgium.

iii. Maps & satellite images

11- European Network of transmission system operators for gas (Entosog), GAS infrastructure Europe, System development map, Brussels, multiple editions 2017, 2018, 2019,2020.

12- Table (1) Satellite images for port said, idku and Damietta

Sensor	Pixel size	Bands	Date	images location
LAND SAT8	30, 30	11	15-06-2020	Idku
LAND SAT8	30,30	11	15-6-2020	Port Said
LAND SAT8	30,30	11	15-6-2020	Damietta

iv. Field study, observation, survey, and interview

1- Frist visit, Port Said, 17 April 2019, visit petro jet plant for pipe coating, ashtoum reserve and locating land use in western Port Said by GPS.
2- Second visit, Idku LNG and Damietta LNG, 17 Oct.2020, locating land use close to LNG plants.
3- Engy Adly, licenses& contracts general manager, Interview, Gas Regulatory Authority, New Cairo, 14 Jan.2020, 12 August,2021.
4- Karem Mahmoud, Executive Director, Interview, Gas Regulatory Authority, New Cairo, 14 Jan.2020.

- Conceptions of gas hubs and theoretical framework

A hub is the point where buyers and sellers exchange the ownership of gas on paper and in physical delivery. The primary function of the hub is to transport gas from suppliers to consumers as per the contracts at their time of maturity (Xunpeng & Variam, 2018, p.168). According to International Energy Agency (IEA), hubs for gas trading can be categorized into physical, virtual, balancing, financial and Benchmark hubs (for more details see Xunpeng & Variam, 2018, pp.168-169).

The natural gas market structure consists of three major components: entry points, exit points and gas market zone. The gas entry points are importation of liquefied gas and re-gasification, gas import via pipelines, and local production. The gas market zone includes the spot and futures markets and gas storage facilities, while the gas exit points include exports of liquefied gas, exported through pipelines and meet local demand needs fig (1).

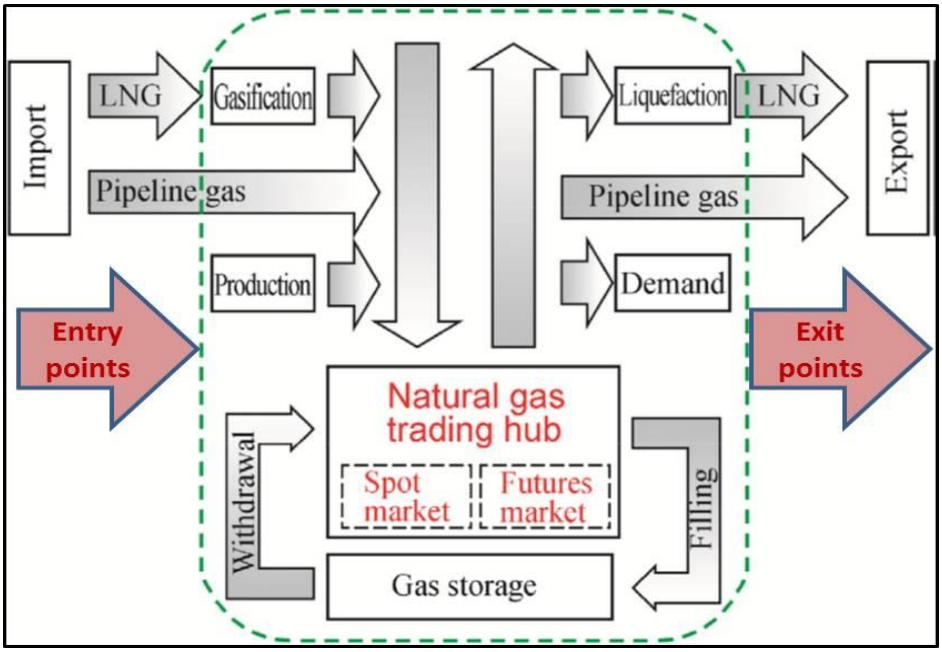


Fig. (1) Schematic diagram of Natural Gas Market Hub Model
Source: Author based on Xiaoguang et al, 2014, p.211

3. Results:

3.1. Geographical and market Requirements for the selection of the optimum Gas trading Hub location in the Eastern Mediterranean Region.

3.1.1. Geographical Requirements

3.1.1.1. Strategic Location

The most suitable location for the regional gas trading hub is determined by the weighted middle position for the production areas of gas, the location of the main consumer markets and the international trade routes. The coastal and island locations over the inland locations are preferred.

3.1.1.2. Interconnection

For the location of the gas trading hub, a high degree of interconnection with a gas pipeline network with neighboring regions and with capabilities that meet the demand for gas within its trading hub is needed. A number of entrances and exits are also considered to be made available to receive and leave the gas for the transmission network.

3.1.2. Proximity to external gas market and gas production regions

To minimize transportation costs, the gas trading hub requires proximity to its key markets. It is preferable to locate the gas trade hub in or near the gas production regions, to ensure its continuous flow without interruption.

3.1.3. Gas facilities

Liquefied natural gas (LNG), regasification floating storage unit (FSRU), liquid natural gas (NGL), low temperature separation (LTS), and liquefied petroleum gas (LPG), these facilities are necessary for gas processing, storage, liquefying and regasification, it must be available with broad capacity to meet the demand for gas.

3.1.2. Market requirements

3.1.2.1. Gas market liberalization, Competition and Maturity of gas market

The key requirement for the development of a liberalized wholesale market and a profitable trading hub is to ensure full liberalization of the manufacturing, commercial and residential sectors; this increases competition between suppliers and allows the end-user to demand more competitive pricing (Heather, 2015, p.5).

It will take considerable time (10-15 years) to develop the Gas Trading hub across several phases, starting with market liberalization and transparency that attract more players. Then, the creation of trading products to increase market participants depending on the underlying contracts to curve progression and thus risk management, create sufficient liquidity for traders to make effective use fig.2.

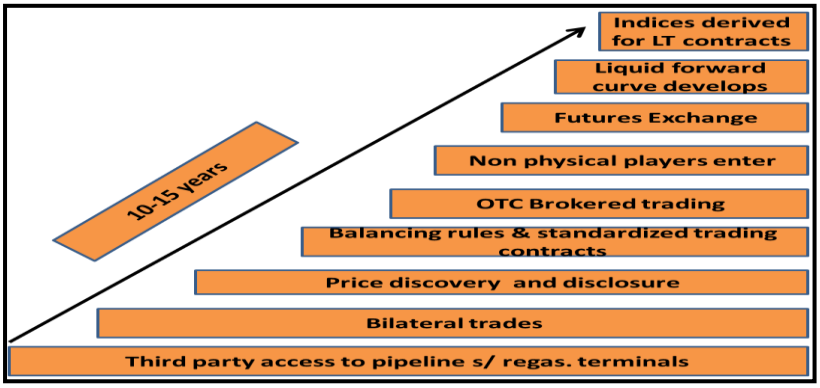


Fig. (2) Evolution of gas trading hub

Source: Author based on Heather, 2015, p.7.

OTC = over-the-counter contracts are bilateral, dealt direct or through

brokers, by voice or electronic media.LT= long term contracts.

3.1.3. Market participants and Number of active suppliers

The number of participants represents not just the ease of trading gas on the hub but also the competition level (Shi & Variam, 2018, p.172). They are the gas market parties that have been licensed to participate in one of the gas market operations, including: shipping, transportation, storage, distribution, supply, marketing, and other forms of gas trading, As well as qualified and unqualified customers (Law No. 196 Regulating Gas Market Activities, 2017).

3.1.4. Market concentration index

The market concentration index can be measured as the sum of the three largest suppliers 'market shares on the gas market as well as the number of major suppliers (i.e., suppliers with market shares equal to or greater than 5 per cent). In those markets where the three largest suppliers have a smaller market share and where many major suppliers operate in the market, the best conditions for competitive gas markets at the national level exist.

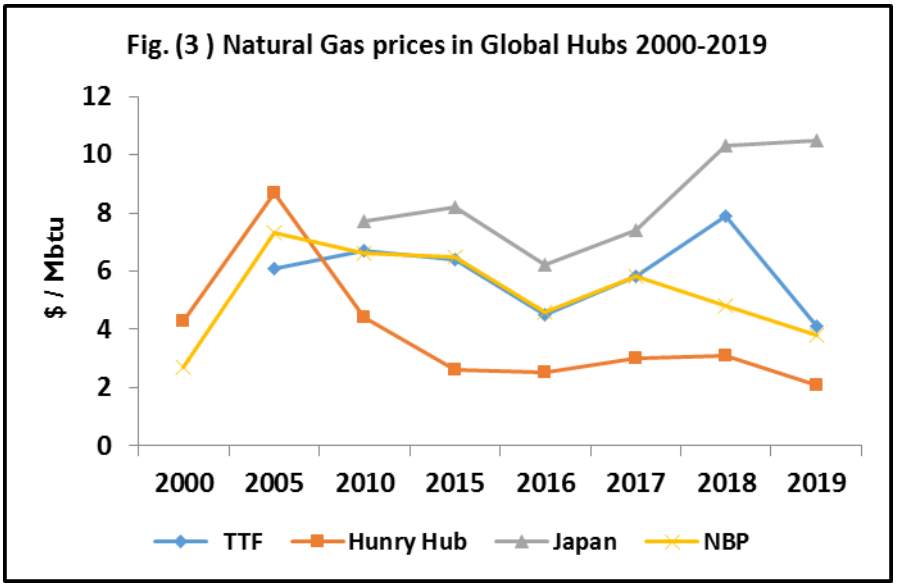
3.1.5. Traded products, volumes, and Platform for gas prices

The traded products are especially interesting because it displays the various product types that are available for trade and offer a guide on their 'popularity' in each of the hubs. The categories of items vary from spot and prompt to months, quarters, seasons and calendar and gas years (Heather, 2015, p.70). Standardizing traded products / contracts by location and time of delivery is crucial to create a successful hub by concentrating liquidity that attracts volume and traders further (Shi & Variam, 2018, p.172).

Trading platforms have the places where gas prices are exposed at various physical locations. An exchange plays a critical role in developing a traded commodity market through five main functions: price discovery, price transparency, flexibility in supply / pricing, physical balance, and financial risk management (Shi & Variam, 2018, p.171). See fig.3.

3.1.6. Tradability Index and Churn Rate

The Index is calculated by giving one point for each of ten contracts along the curve. The maximum score is 20. The ten contracts are: Within day, Day ahead, Balance of month, Month ahead to three years ahead**.**



Source: author, based on Eni, World Gas and Renewable .Review, 2018, 2019:.49, 52
Gas Market Regulatory Authority, 2020:6

The Net Market Churn is the EU definition of total trades/physical consumption at the hub; the Gross Market Churn is total trades/total physical demand (i.e., throughput including exports). Commodity markets are deemed to have reached maturity when the churn is more than 10 times. Some traders will not participate in markets with a churn of less than 10 and many financial players will only participate when the churn is above 12 times (Heather, 2015, pp.78-83).

Table (2) Model for selecting the optimum locations for the Natural Gas Hub in East Mediterranean region 2020.

criteria	Italy	Syria	Egypt	Israel	Greece	Cyprus	Palestine	Gordon	Turkey	Lebanon	Variables scores
strategic location(1)	2	1	2	1	2	2	1	0	2	1	8
High degree of interconnectedness and interconnection capacity bcm(2)	38	10	17	7	4.9	0	0	10	46.9	0	10
Number Entry- exit zones(3)	0	0	628	0	44	0	0	0	10	0	9
Proximity to external gas market(4)	2	1	1	1	2	2	1	0	2	1	6
Available Gas production bcm 2018 (5)	5.2	3.5	55.8	9.7	0.01	0	0	0.01	0.41	0	5
Facilities, LNG plant capacity bcm.(6)	0	0	12	0	0	0	0	0	0	0	8
Facilities, FSU. Capacity bcm (7)	15.3	0	9.3	2.7	5.4	0	0	5.2	35.7	0	7
Other facilities LPG,NGL and LTS bcm (8)	0	0	135	0	0	0	0	0	0	0	3
Number of Market participants(9)	541	0	14	2	5	0	0	1	33	0	9
Level of liberalization in the gas market %(10)	47	0	0	100	0	0	0	0	81	0	10
Market concentration index% (11)	37	0	0	100	100	0	0	100	90	0	6
Trade volumes bcm (12)	65.02	0	6.57	0.7	4.82	0	0	3.78	48.86	0	9
Churn Rate (13)	0.93	0	0.11	0.06	1.02	0	0	1.05	1.02	0	10

Source: author´s calculation based on Mediterranean Energy Regulators, (2018), pp.13-16, Mediterranean Energy Regulators, (2017), p.10, 12, European Federation of Energy Traders, Gas Hubs -Best practice development model, 2018.

criteria	Italy	Syria	Egypt	Israel	Greece	Cyprus	Palestine	Gordon	Turkey	Lebanon	Variables scores
strategic location(1)	0.16	0.04	0.16	0.04	0.16	0.16	0.04	0	0.16	0.04	8
High degree of interconnectedness and interconnection capacity bcm(2)	0.34	0.02	0.06	0.01	0.005	0	0	0.02	0.52	0	10
Number Entry- exit zones(3)	0	0	0.99	0	0.004	0	0	0	0.002	0	9
Proximity to external gas market(4)	0.16	0.04	0.04	0.04	0.16	0.16	0.04	0	0.16	0.04	6
Available Gas production bcm 2018 (5)	0.008	0.003	0.95	0.02	0.0001	0	0	0.0001	0.0041	0	5
Facilities, LNG plant capacity bcm.(6)	0	0	1	0	0	0	0	0	0	0	8
Facilities, FSU. Capacity bcm (7)	0.13	0	0.04	0.005	0.015	0	0	0.015	0.78	0	7
Other facilities LPG,NGL and LTS bcm (8)	0	0	1	0	0	0	0	0	0	0	3
Number of Market participants(9)	0.99	0	0.006	0.0001	0.0008	0	0	0.00003	0.03	0	9
Level of liberalization in the gas market %(10)	0.11	0	0	0.53	0	0	0	0	0.34	0	10
Market concentration index%(11)	0.034	0	0	0.25	0.25	0	0	0.25	0.20	0	6
Trade volumes bcm (12)	0.63	0	0.0062	0.00049	0.00034	0	0	0.00019	0.35	0	9
Churn Rate (13)	0.93	0	0.11	0.06	1.02	0	0	1.05	1.02	0	10

Source: author's calculation based on Mediterranean Energy Regulators, (2018), pp.13-16, Mediterranean Energy Regulators, (2017), p.10, 12, European Federation of Energy Traders, Gas Hubs -Best practice development model, 2018.

The internal location = 0, the location on the sea = 1, the location on two seas or island = 2.

Less than 500 km=2, 500-1000km=1, more than 1000km=0

Table (4) Results of TOPSIS Analysis for gas trading hub in East Mediterranean Region, 2020

The results of the TOPSIS analysis showed that according to

State	Si+ values	Si- values	Relative closeness values	rank
Italy	0.0097	0.140	0.939	1
Syria	0.0074	0.0014	0.159	7
Egypt	0.150	0.160	0.516	2
Israel	0.170	0.043	0.201	5
Greece	0.160	0.079	0.330	4
Cyprus	0.00	0.00	0.00	8
Palestine	0.00	0.00	0.00	8
Gordon	0.136	0.031	0.192	6
Turkey	0.140	0.126	0.473	3
Lebanon	0.00	0.00	0.00	8

geographical and market criteria, Italy, Egypt, and Turkey, respectively, are the top three locations for localization of the regional gas trading hub. However, for the following reasons, Egypt is the best location for the concentration of the regional gas trading hub.

4. Discussion and analysis

4.1. Reasons for localization the Gas Trading Hub in Egypt

4.1.1. Strategic location

In terms of its strategic location, Egypt enjoys a very significant role in world trade. As the home of the Suez Canal, it is an important part of the eastern-western most direct trade route. From the perspective of gas supply and trading, its privileged position is strengthened by Egypt's proximity to some of the world's largest natural gas reserves, including: Qatar, Iran, Saudi Arabia, Libya and Iraq via Jordan.

It is adjacent to the main gas demand in Europe, which has long been a matter of concern for European energy policy makers since exposure to Russian gas supply lines. Europe is looking at ways of reducing its dependence on Russian gas (Keenan& Vinter, 2019).

4.1.2. Natural Gas Reserves, Recent Discoveries, production, and

consumption

Egypt's natural gas reserves are found in different geographic locations including two onshore areas, the Western desert, and the Nile Delta, and two offshore areas, the Suez gulf, and the Mediterranean Sea. Owing to the recent exploration activities, the proven gas reserves rose from 1.4 trillion m3 in 2000 to 2.2 trillion m3 in 2019(Eni, World Gas and Renewable Review, 2020:5).See Appendix 1.

One of the biggest changers for Egypt has been the recent discovery of Zohr gas field Eni Company's discovered this field in 2015. It has an estimated reserve of 30trn cubic feet. Zohr field production began in 2017 with an initial output of 350 m cubic feet per day, it have a production capacity of 2,7bn cubic feet per day by the end of 2019.

Other recent discoveries have been made in the BP West Nile Delta concession, including the **Noor gas field**. In March 2015, BP announced the discovery of the **Atoll gas field**, with output 350 mmcf / d in 2019, and is forecast to reach 1.5 trillion cubic meters (Strategic business advisors, 2019, p.5). The **Nooros gas field** was discovered in July 2015, Owned by ENI, and BP (50/50). In March 2018, ENI announced that a production rate of 32 mmcf / d had been achieved for the field. In September 2018, the Egyptian General Petroleum Corporation (EGPC) signed an E&P agreement with Shell and Petronas (USD 1 billion) to drill 8 wells in WDDM. The **W**estern **D**elta **D**eep **M**arine, concession in the Mediterranean Sea consists of **19 fields, 12 of** which are in production mode (Scarab, Saffron, Simian, Sienna, Sapphire, Serpent, Saurus, Sequoia, SimSat-P2, Sapsat-1, Sapsat-2, and Swan) (Strategic business advisors, 2019, pp.5-6).

4.1.3. Gas industry chain

Egyptian Gas industry chain consists of gas fields situated in the Nile delta, Mediterranean Sea, Western Desert and Suez Gulf, connects with approximately 36 facilities, 19 LTS units, 2 LNG units, 2FSRU units, 10 LPG units and 3 NGL units. These facilities were connected to distribution centers estimated at 16 centers: 5 in Abu Qir, 4 in Cairo, 3 in Suez, 2 Damietta and Port Said centers. Such distribution centers transport gas to customers including 58 power plants (60%), 13 manufacturing areas (10%), 8.8 million residential units (2019: 10.7 million) (18%), and 187 gas fueling stations (0.1%) in

2020 (GSCO,2020, P.17. fig.4.

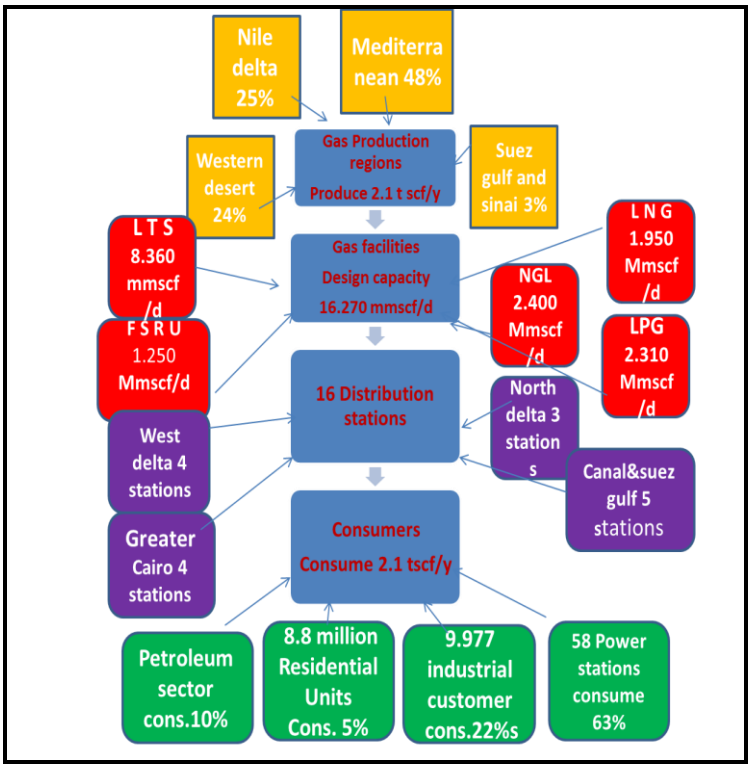


Figure. (4) Egypt's Gas industry commodity chain model in 2019.
Source: Author based on petroleum ministry 2019.

This Gas industry commodity chains are connecting by the National Gas Grid length reached 51,000 km with a capacity of about 2010 -240 million cubic meters per day to maintain gas pressure across Egypt's consumption regions, in 2018-2020. These regions including North Cairo, Southern region, Damietta, Suez, Canal, East &West Alex., Shabsheer, Talkha, Red Sea, and North and South Sinai Respectively, according to the daily consumption capacity (GSCO,2020). See fig.5.

- FSRU

The Gulf of Suez is also undergoing major infrastructure development. Arab Petroleum Pipelines Company, a partly state-owned Egyptian company, is constructing a new 2.5 km wharf with three berths to receive LNG and petroleum carriers. The wharf will allow the Egyptian Gas Holding Company to permanently install an FSRU to receive LNG imported from anchored LNG carriers at the Wharf. One with a capacity of 3 BCMY and the other with a capacity of 7 BCMY Both are in Sokhna Port, Red Sea (Abu Bakr, 2016, p.9).

4.1.4. Existing interconnection infrastructure

- Egypt has a large export infrastructure for natural gas: Arab gas pipeline and EMG pipeline.

Arab gas pipeline

The Arab Gas Pipeline with 10 bmc capacity passes through Jordan from Egypt's Sinai Peninsula and extends through numerous sections into Syria and Lebanon. The first section of the Arab Gas Pipeline, linking Port Said with Aqaba through Al Arish, (497 km) was run in 2003**.** A second section has been run in 2006 for 390 km from Aqaba to El Rehab on the Jordan / Syrian border**.**

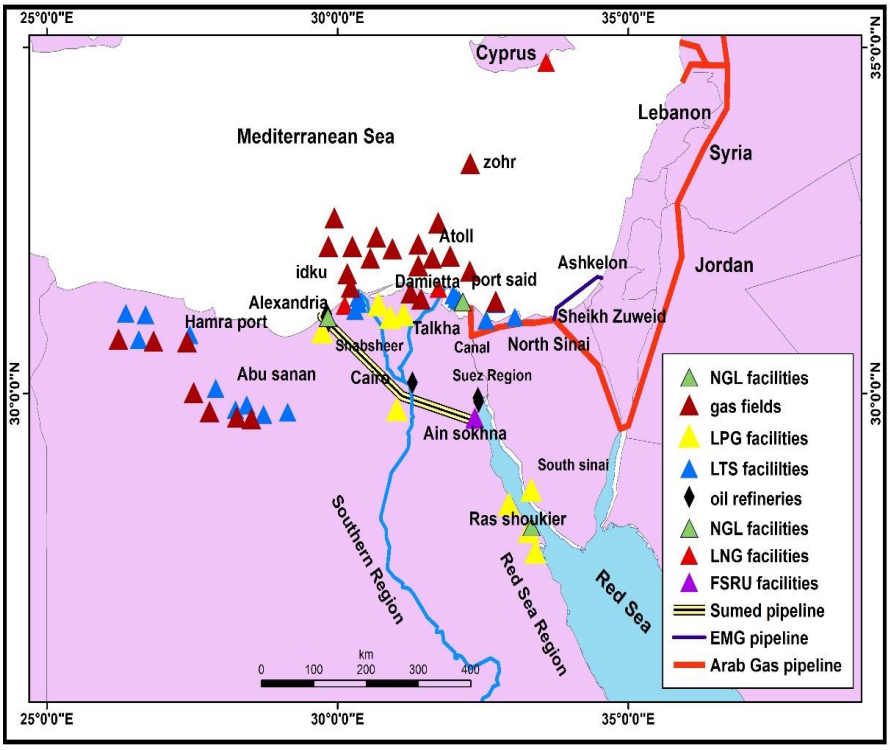


Fig. (5) Egypt's gas export infrastructure and facilities 2019.
Source: Author, based on Petroleum Ministry, 2018, 2019.

The third section of the Arab Gas Pipeline passes through Damascus for 30 km across the Jordan-Syrian border in 2007 and then to city of Homs in Syria for 317 km in 2008**.** The Arab Gas Pipeline's link to Lebanon is the fourth section of the pipeline completed thus far and then to turkey (Mediterranean Energy Regulators, 2018, p.18).See Fig.5.

- EMG pipeline

There is a section of pipeline that connects Egypt to Israel runs at a capacity of 7 bmc / year for 100 km in 2008. This section is known as the Arish-Ashkelon pipeline or the EMG the reference to East Mediterranean Gas Group (Strategic business advisors, 2019, p.7).

4.1.5. **The** Supplementary facilities:

- Suez Canal

Total oil and other liquids (crude oil and refined products) and LNG accounted for 17 percent and 6 percent of total Suez Canal freight,

respectively. it increased the depth of the canal to 66 feet to enable more than 60 percent of all tankers to transit the canal. Therefore, since 2010, nearly 93 percent of bulk carriers and 100 percent of container ships have been able to pass through the Suez Canal (US Energy Information Administration, 2017).

- SUMED pipeline

The 200-mile SUMED Pipeline, or Suez-Mediterranean Pipeline, transports crude oil from the Red Sea to the Mediterranean Sea via Egypt. The crude oil flows into two 42-inch diameter parallel pipelines with a combined pipeline capacity of 2.34 million b / d. Oil flows north from the Ain Sukhna terminal along the Red Sea coast to the Sidi Kerir Mediterranean Sea terminal (US Energy Information Administration, 2017).

- In addition, Alexandria has 4 refineries with capacities 21.7 mmty and Suez has 2 refineries with capacities 12.4 mmty in 2019, Gas facilities are then related to oil refineries due to it the processing of LPG (Egyptian general petroleum corporation 2019).
- The efficiency of a natural gas infrastructure of east Mediterranean countries
- Liquefaction and Regasification capacities

Egypt is only state in east Mediterranean region which owns gas liquefaction units with capacity 9.8 bcm, 2019.

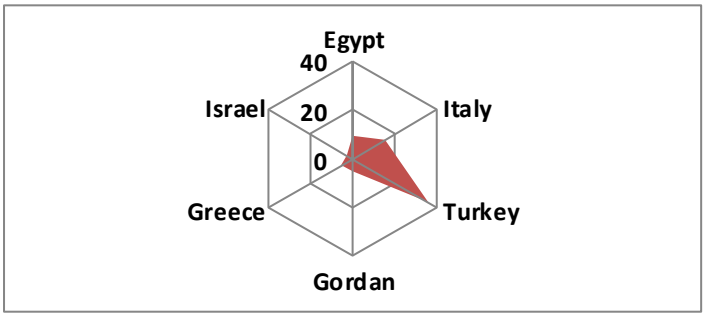


Fig. (6) Regasification capacity in East Mediterranean states 2019 (bcm).

Source: Author, based on Eni, World Gas and Renewable Review, 2019, pp.46, 48.

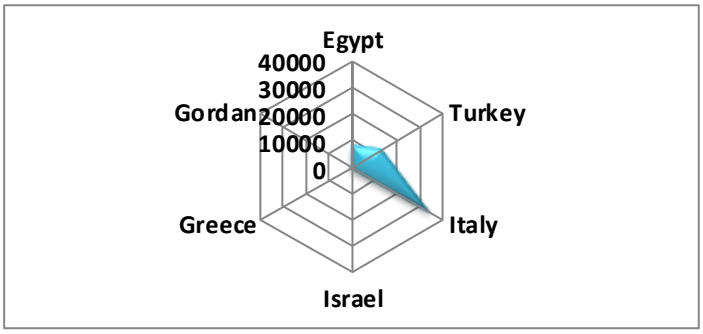


Fig. (7) Pipeline length in East Mediterranean states 2018(km).
Source: Author, based on Mediterranean energy regulators, 2018, pp.29-34.

In the Eastern Mediterranean Region, there are six countries that have regasification capacity: Turkey, Italy, Egypt, Greece, Jordan, and Israel. Turkey owns four of the terminals, and each of Italy and Egypt has three terminals. Greece, Jordan, and Israel each have one terminal with different capacity each Fig.6. pipeline length was showed in fig.7.

4.1.5. Number of active suppliers and Market concentration index

In the European gas markets, it is likely important to spur operation and improve liquidity by a minimum of ten active companies. This analysis describes 'active' participants as those who trade at least once a week (Heather, 2015, p.68). Egypt has 14 active Household Gas Suppliers (Mediterranean Energy Regulators, 2017, p.11).

Egypt is not included in Market concentration index, as the market for gas remains strictly regulated (Mediterranean Energy Regulators, 2017, p.12).

4.1.6. Size of Gas market in East Mediterranean

Total gas production in the Eastern Mediterranean Region was 74.79 bcm, most of which are concentrated in Egypt (63.7 bcm 2020), Israel, and Italy, respectively, while total consumption was 195 bcm, gas consumption centers are in Italy, Egypt (59 bcm 2020) and Turkey respectively (Eni, World Gas and Renewable Review, 2019:10, 19, BP, Statistical Review of World Energy, 2019).

Total gas imports in the Eastern Mediterranean Region amounted to 124bcm, which were taken by Italy and Turkey on more than 112 bcm, while the total exports reached 4.7 bcm, about 3.7 bcm (4.7bcm 2020) came from Egypt only (Eni, World Gas and Renewable Review,

2019:35, 38). Accordingly, Egypt is the largest producer, largest consumer, and largest exporter of natural gas in the eastern Mediterranean.

Eastern Mediterranean countries formed regional gas market Forum in Jan.2019. The forum aims to create a regional gas market that ensuring supply and demand. The announcement is part of efforts to transform the Eastern Mediterranean into a major energy hub (Reuters: JANUARY 14, 2019).The forum involves ;Egypt, Cyprus, Greece, Israel, Italy, Jordan and the Palestinians, As well as The US energy secretary and the European Union director general of energy, France and World Bank (.al-monitor. /2019/08/5). Turkey has put forward the idea of establishing a north-eastern Mediterranean gas forum with Northern Cyprus, Lebanon, and Syria (thearabweekly. 20/01/2019)

4.1.7. Legal procedures and international agreements

New Gas Market Law

The implementation of 196/2017, GasReg law is central to the goal of the Egyptian government to become a regional gas trading and export hub. One of the primary objectives of the new law is the liberalization of Egypt's gas sector, allowing the private sector for the first time to utilize Egypt's state-owned gas transmission and distribution infrastructure and to participate in gas trading activities. The Gas Law focuses on the regulation of downstream and midstream activities – it does not apply to the upstream sector – this will remain subject to the existing legal framework (Law No. 196 Regulating Gas Market Activities, 2017).

The Gas Law groups regulated activities into two categories: service activities and market activities. In broad terms, service activities involve Networks and facilities which operation of gas grids and facilities through transmission, storage, distribution of gas as well as liquefaction/regasification activities. Market activities include activities that benefit from networks and facilities including the shipping and supply of gas.

Several companies have already taken advantage of the implementation of the new Gas Law and have applied and secured licenses to import LNG and trade gas within the Egyptian market. These include Gas distribution and supply system operators: The Egyptian Natural Gas Holding Company (EGAS)(only shipping and supply), Egyptian Natural Gas Company (GASCO)(also gas

transportation), Egyptian Company for the Distribution of Natural Gas to Cities (Town Gas), Regional Gas Company (Regas), Fayoum Gas Company, The Egyptian Company for Technical Services and Equipment Maintenance (SEANCO) National Gas Company (NTGAS), Maya Gas Company, Cairo Gas Company, Sinai Gas Company, TAQA Arabia, Egypt Gas Company, Overseas Gas Company, Trans Gas Company, and Nubaria Natural Gas Company(only supply)(Engy Adly, August 2021). In addition to, Energy Fleet a company based in Panama, BP, and Russian energy giant, Rosneft.

Accordingly, the Egyptian Natural Gas Holding Company (EGAS) has a monopoly on gas shipping, as it is the only party that contracts with network operators and facilities to use them if they are made available to others. The Egyptian Natural Gas Company (GASCO) also monopolizes the management and operation of the gas transmission system through the national network of high-pressure pipelines, including pressure stations, measuring equipment and devices, and others, while the rest of the companies practice the management and operation of the gas distribution system through a network of low and medium pressure pipelines. It carries out the supply and sale of gas owned by it or a third party to consumers or to another supplier in accordance with the plan to liberalize the gas market. Geographically, gas is supplied in Egypt from four areas: Idku, Ain Sokhna, Sheikh Zuweid and Ras Shukair, respectively, according to the daily production capacity total of 95 MMSCMD (GSCO, 2020). See fig.5.

The Gas Market Activities Regulatory Authority, in coordination with the Egyptian authorities concerned, will prepare a comprehensive plan to liberalize the gas market to achieve a competitive market, given that the plan includes market liberalization phases, the time for each stage, the steps required to enforce it and the transition criteria from one stage to the next. It wasn't done until August 2021 (Law No. 196 Regulating Gas Market Activities, 2017:16) (Engy Adly & Karem Mahmoud 2020, 2021 interview).

The application of the Gas Law raises several questions. For example, it is not clear from the Gas Law how access to Egypt's gas transmission and distribution infrastructure will be regulated and prioritized to avoid discrimination and to promote competition. Similarly, there is no visibility on whether third-party access to the

Damietta and Idku LNG plants will be implemented, if at all, and if so, how and on what terms capacity will be allocated (Keenan& Vinter, 2019).

In addition, a strategic partnership on energy between the European union and Egypt 2018 -2022, which Support Egypt's role in becoming and sustaining a Gas and Electricity Hub in the Mediterranean (Strategic business advisors, 2019, pp.8-9).

4.2. Geographical and economic requirements for selecting optimum site for Gas trading hub in Egypt

4.2.1. Port Said Gas complex

The United Gas Derivatives Company (UGDC), the El Gamil Gas Plant (the Petropel Complex), the Pharaonic Petroleum Company, the International Pipeline Factory, produce 734.043 tons. the Propylene and Polypropylene Factory, each with a capacity of 350,000tpa. the Zohr Gas Field Development Project, a total potential of about 30 TCF. the Petro jet Pipeline Coating Factory, photo.3.4 as well as other facilities and the companies labor camps, are all part of the Port Said Gas Complex fig.8.

UGDC Port Said Plant has been designed for deep extraction of NGL cut from a mixed feed gas; it is classified as one of the largest NGL plants in Egypt regarding the plant processing capacity reaching about 1350 (MMSCFD). The plant is designed to produce valuable liquids, namely propane, LPG or butane and condensate. In future, it is possible to retrofit the plant in order to produce also ethane.

Basically, the gas feed comes from the Egyptian Gas National Grid via two pipelines from PHARONIA (Habi, and Akhen, taurt, Atoll gas fields) and PETROBEL plants (Al Temsah, Port Fouad gas fields) and the residue gas is sent back to the Gas Grid. LPG is then loaded from NGL Plant in Port Said to the LPG bottling plants in Shata & Damietta through LPG pipeline, while DNG is stored in two bullets, then DNG is loaded to the refinery at Suez. For the propane product; it has two ways of loading, either to Damietta facilities to be stored and exported or loaded to the petrochemicals factory next to UGDC port-said plant united gas Derivatives Company (United Gas Derivatives Company web site, 2020).

Eni plans to complete establishing the onshore pipeline connecting Zohr gas treatment plant in Port Said to Damietta Liquefaction plant by April 2019. Eni had contracted to pump 750 million standard cubic feet per day (mmscf/d) to Damietta plant (egyptoil-gas: april/2020).

Table (1) Model for selecting the optimum sites for the Natural Gas Trading Hub in Egypt

Variables/ locations	Marsa Matruh, El Hamra port	Idku	Damietta	El Arish	Ain Sukhna	Port Said	Taba	Variable weights
1- Central location	0.5	1	1	0.5	0.5	1	0.5	1
2- Proximity to gas transmission networks	0.5	1	1	0.5	0.5	1	0.5	1
3- distribution networks	0.6	0.7	0.6	0.4	0.6	0.6	0.4	0.7
4- Proximity to Gas facilities(storages)	0.4	0.7	0.7	0.4	0.7	0.7	0.4	0.7
5-Facilities, LNG	0	1.2	0.8	0	0	0	0	1.2
6- Facilities, FSU	0	0	0	0	1	0	0	1
7- Other facilities, LPG, NGL and LTS	0	0.7	0	0	0.4	0.7	0	0.7
8- Size of internal gas market	0.2	1	1	0.2	0.5	0.5	0.2	1
9- Production capacity of nearest gas fields	0.2	0.6	0.2	0.2	0.2	1	0	1
10-accessibility to external gas market	1	1.4	1.4	1	1	1	0	1.4
Scores Total	3. 4	8.3	6.7	3.2	5.4	6.5	2	10

Source: Author based on American Petroleum Institute, 2014, Understanding Natural Gas Markets p.17: Available at https://www.api.org 28- Ministry of Petroleum, (2017-2018), European Federation of Energy Traders, Gas Hubs -Best practice development model, 2018.

1- Central location=1. Periphery location=0.5
2- Node of transmission=1 available of transmission network=0.5
3- Distribution center below 50 km=0.7, 50-100km=0.6, 100kmabove=0.4
4- Gas facilities one=0.4 multi gas facilities=0.7
5- NO LNG=0 one train=0.8, two train=1.2
6- NO FSU=0, ONE FSU=0.5, two FSU=1
7- No LPG &LTS-0, ONE LPG&LTS=0.4, two and more LPG &LTS=0.7
8- Large market (above million) =1, medium market (0.5-1 million) =0.5, small market (below 0.5 million) =0.2
9- No production=0, Production above 2000mmscf/d=1, 1000-2000mmscf/d=0.6, below 1000 mmscf/d=0.2
10- No port = 0, available port=1, A specialized port=1.4

4.2.2. New Damietta port Gas complex

The Egyptian Spanish Company for Liquefied Gas, the Egyptian Company for Methanol, a Greenfield 1.3 million ton per year**,** (Egypt Oil and Gas, 2019, P.37),Photo No. **(2).** and the United Company for Natural Gas Derivatives, as well as fertilizer and textile plants, are all part of the new Damietta port gas complex.

Natural gas is captured from Port Said gas plants and fields, as well as Abu Madi gas fields and processing by the Egyptian Spanish Company for Gas Liquefied.

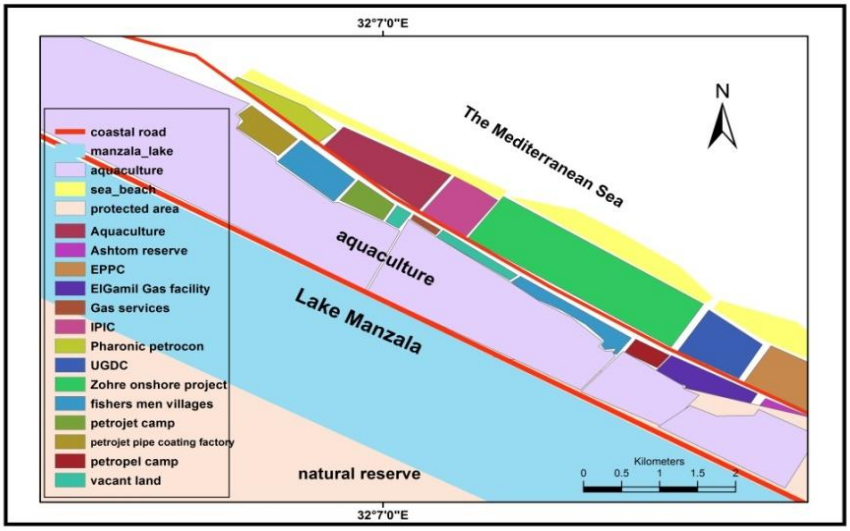


Fig. (8) Port Said gas complex 2020.
Source: Author based on field observation and survey, April 2019.
Image satellite, 2020, google earth, 2020

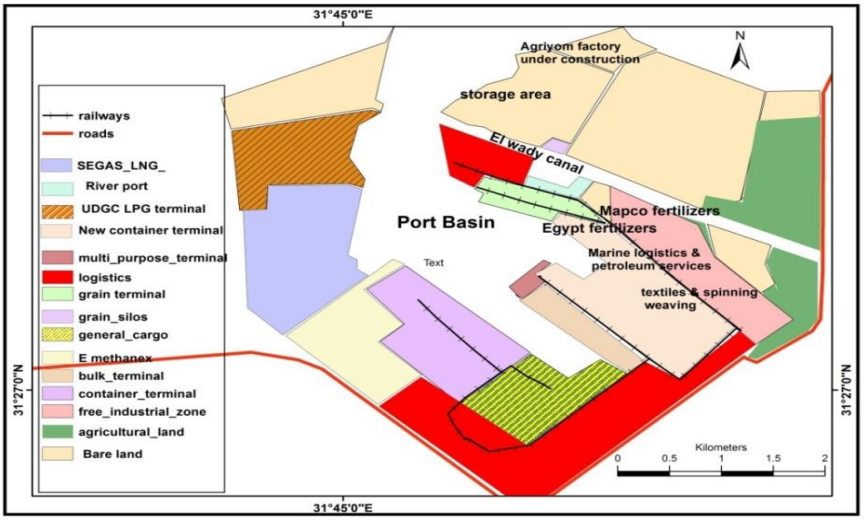


Fig. (9) New Damietta port gas complex 2020.
Source: author based on Damietta port authority, 2021, field observations and survey, Oct.2020. image satellite 2020, google earth,2020.

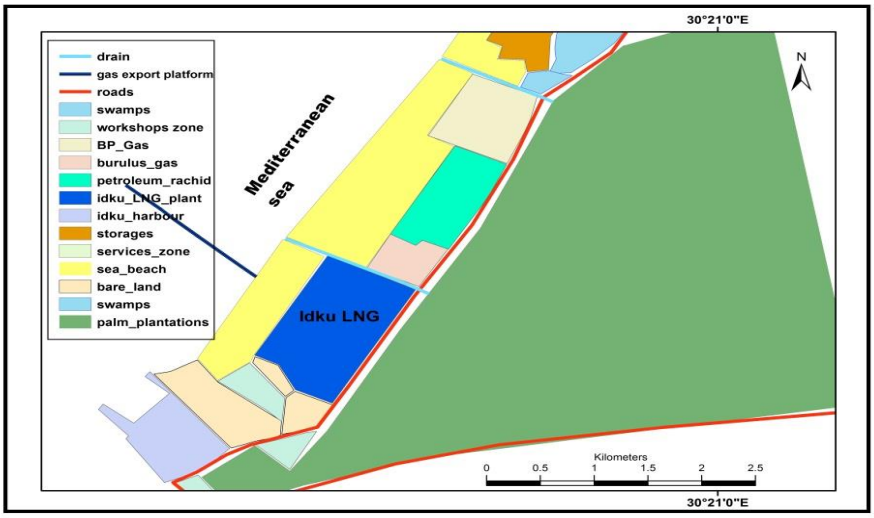


Fig. (10) Idku gas complex 2020.
Source: author based on, field observations and survey, Oct.2020.
Image satellite 2020, google earth, 2020

The Damietta LNG plant has the capacity to produce 5 m tons of LNG unit situated in the new port of Damietta on an area of 280 acres, comprising two tanks with a capacity of 150,000 m3 each. The Damietta plant is owned and operated by the Spanish Egyptian Gas Company, a Union Fenosa Gas subsidiary which is a joint venture between Eni and Unión Fenosa of 50/50 via shareholdings owned by the Egyptian Natural Gas Holding Company and the Egyptian General Petroleum Corporation, the Egyptian government also has a 20 percent stake. Damietta received first LNG shipment in February 2021with 60000 tons from Singapore and re-export to Bangladesh (Egypt Oil & Gas, 2021, p.6).

4.2.3. Idku Gas Complex

Egyptian LNG, Rashid Petroleum Company, Burullus Gas Company, total capacity of Rachid and Burullus gas fields are 1100 mmcf/d, (egyptoil-gas.web 2020), and West Nile Natural Gas Bp are all part of the Idku gas complex, beside gas services and workshops. The Idku gas liquefaction unit is specifically in Al Maadia village, which operates on an area of 390 acres using Free Zone system. It has two storage depots. The capacity of the storages is 140,000 m3. It includes a specialized natural gas export terminal, and a 2.4 km long loading dock. The project is divided into two gas liquefaction units, each with a capacity of 3.6 million tons (Al Sudaimi, 2007, pp.479-484). See photo (2).

Egyptian LNG was received Natural Gas from gas fields: Taurus, Giza, fayoum, with capacity 500 mmcf/d & Raven with capacity 950 mmcf/d (EGAS, 2020), and plants in the north Rachid and western deserts. The Idku LNG facility now operate at about 50 percent of its nameplate capacity, Egypt's Petroleum Ministry planned to have the Idku plant fully operational by 2020/21(Keenan& Vinter, 2019).

4.3. Challenges faced Gas trading Hub in east Mediterranean Region:

4.3.1. Economic challenges

The total cost of taking the gas from Israel and Cyprus to Egypt, liquefying, transporting it to Europe and regasifying, making it difficult to compete with piped Russian gas, but Egypt's own offshore gas production may change the situation. As such development of various gas field projects as North Alexandria, Atoll, and Zohr get underway, this should enable Egypt to resume LNG exports from Damietta and Idku by 2022. (Ellinas, et al, 2016, p.26). Fundamental issue is commercial feasibility of gas re-exports from Egypt. Under current market conditions, highly unlikely that any third-party gas supplies could be re-exported from Egypt's LNG infrastructure, but this could change (Fattouh, 2019, p.4).

Rising local demand in Egypt, insufficient export capacity to liquefy all the surplus local and regional gas production, pricing risks and incomplete reforms, which may turn regional gas players to other optimal export routes (Strategic business advisors, ,2019, p.17). Egypt gas exports not liquefied gas, which leads to the loss of 20% of the primary energy produced and thus exported in the form of compressed, gas provides these large losses. The export of gas by FOB system (free on board) at the cargo port loses 10% of the gas during the transport. Therefore, CIF cost insurance and freight delivery system at the discharge port reduces these losses. In Singapore LNG applied (Des) delivered ex ship where seller will make the goods available on a ship in a particular port, and the buyer is responsible for paying for the goods to be put on land and transported to where they are needed (Xunpeng&Variam,2018, p.173).

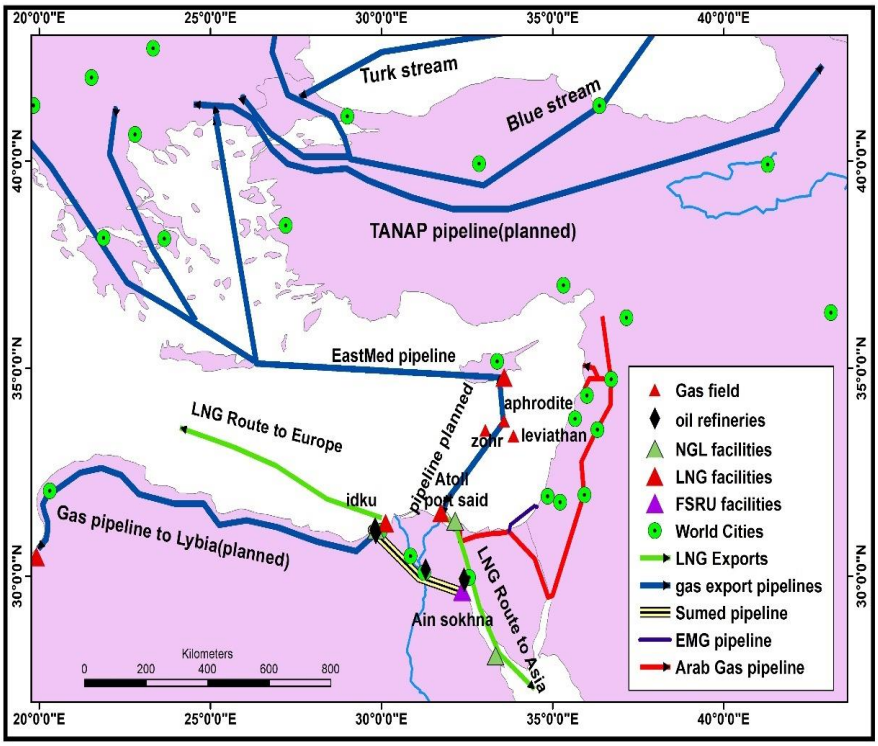


Fig. (11) a comparative gas Export Routes for Eastern Mediterranean Region2020**.**

Source: Boustros, Nov.2018, pp.20, 25. 10- European Network of transmission system operators for gas, 2018, 2019, 2020 (EU Rim Policy and Investment Council, 2012, p.16)

East Med pipeline

Cyprus, Israel, and Greece signed on January 2, 2020, a preliminary agreement in Athens to construction of a gas pipeline known as East Med for a length of 1900 km to transport Israeli and Cyprus gas to Greece and then to Europe 2025. This trend is encouraged by the United States to reduce the European Union's dependence on Russian gas. See Fig.11.

On January 8, 2020, the Russia and the Turkey inaugurated the gas pipeline called the Turkish Torrent Line to transport gas to eastern and southern Europe. The Russian gas line starts from the station "Ruskaya" in Anapa on the Black Sea, the source of the project with

natural gas, which crosses the Black Sea to the town of "Koy Koy" in northwest of Turkey, where huge tanks will be built to export gas to European countries fig.11. On2 November 2015, Russia officially announced that it had agreed with Turkey to reduce the capabilities of the gas flow project and reduce it to almost half, so that the project consists of two transport lines with a capacity of 31.5 billion cubic meters annually. 15.75 billion Cubic meters of gas for Turkey, 15.25 billion cubic meters of gas for export to southern and eastern European countries, the pipeline with a length of 1160 km and with a cost of $ 13 billion (tellerreport.web 2020-01-07--)

4.3.2. Political challenges

The three key disputes have emerged in the region: the first concerns the waters offshore Cyprus, while the second concerns the EEZ delimitation between Israel and Lebanon,and the third issue is maritime border agreement between Libya and Turkey.

i) Cyprus: in 2004, Turkey notified to the United Nations that it does not recognize the previously mentioned 2003 treaty between Cyprus and Egypt for the delimitation of theirs EEZs, (Exclusive Economic Zone) claiming that delimitations in the offshore of Cyprus should be agreed by all states in the region including Turkey, based on the principle of equity. This issue is related to the Cyprus issue, following by the proclamation of the 'Turkish Republic of Northern Cyprus' ('TRNC') in 1983, that the United Nations declared legally invalid and that only Turkey recognized. After the gas discoveries in offshore Israel and Cyprus, Turkey signed an agreement with the 'TRNC' in 2011 for the delimitation of the continental shelf.

ii) Israel-Lebanon: this dispute emerged in 2010, after the previously mentioned treaty between the Republic of Cyprus and Egypt was signed. Lebanon claimed the treaty violated its own rights over the seabed and waters (clearly, where hydrocarbons are supposed to be present) Where the Israeli Tamara gas field is located off the coast of Sidon, Lebanon.

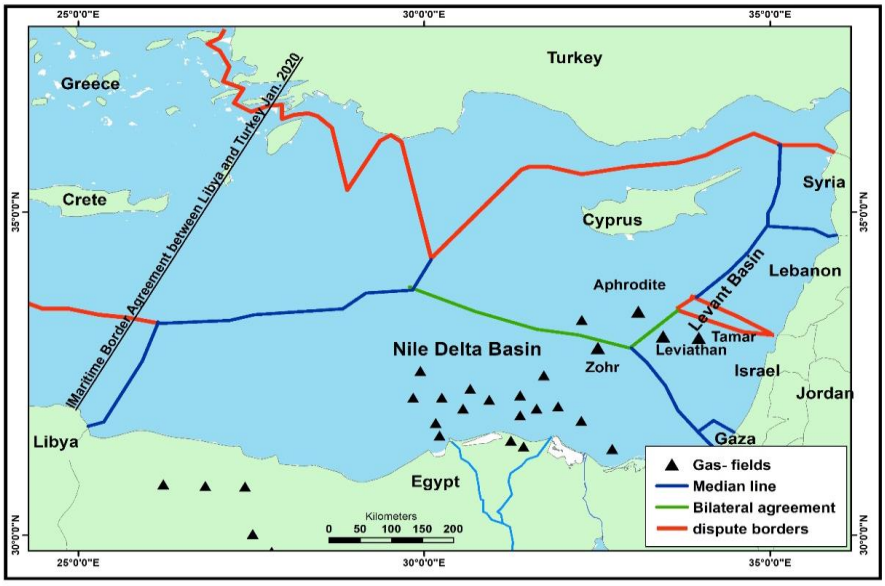


Fig.12. Maritime borders and main gas fields in Eastern Mediterranean 2020

Source: Author based on European parliament, 2017, p.19.
Maritime border agreement between Libya and Turkey, Jan.2020

Both the UNCLOS the United Nations Convention on the Law of the Sea and customary rules of international law provide several means for the peaceful settlement of maritime boundary issues, so there is no reason why these two Eastern Mediterranean disputes could not be solved. However, as also outlined by the UNCLOS, states should behave in good faith in order to reach such delimitation agreements. For this reason, only a stabilized geopolitical environment in the Eastern Mediterranean would allow the resolution of these disputes (European parliament, 2017:19-20).

iii) Turkey signs maritime boundaries deal with Libya

Greek announced that any maritime accord between Libya and Turkey "ignores something that is blatantly obvious, which is that between those two countries there is the large geographical land mass of Crete, While Egypt condemned the deal as "illegal and not binding or affecting the interests and the rights of any third parties". (Reuters: 28 Nov. 2019**).**

International gas companies played a vital role in east

Mediterranean. American Noble discovers Tamar gas field and leviathan in Israel and discover Aphrodite gas field in Cyprus while Eni announced the discovery of zohr in Egypt and Total Explores in Lebanon (European parliament, 2017, p.17).

4.3.3. **Technical challenges**

Egypt is not an EU member-state and lacks all else required to establish a virtual hub. However, it has the potential to become a physical trading hub, with gas exported in the form of LNG (Ellinas, et al, 2016, p.26).

Key obstacles to the development of a regional gas export project are the commercial viability of exporting gas from third party sources and the formulation of contractual arrangements and inter-governmental agreements that would be acceptable to all the parties. Focusing on the commercial aspects only shows that under present international gas market conditions, re-exporting Cypriot or Israeli gas through Egypt at competitive prices could be quite challenging **(**Ouki, 2018, p.2).

The depth lines in the Mediterranean play a clear role in the exploitation of natural gas. The high depth of water in the eastern Mediterranean line for transporting Israel and Cyprus gas to Europe via Greece may lead to technical difficulties and high costs of constructing the pipeline.fig.13.

The project East Med gas pipeline, financially and politically supported by the European Commission, proposed to transport 8-16 billion cubic metres annually of natural gas through a pipeline – more than 2,000 kilometres long and with depths in some locations exceeding 2,000 metres – across the eastern Mediterranean. With a cost exceeding €6 billion, the pipeline would transport in the first stage Israeli and Cypriot gas to Greece and offers the European Union a good alternative to Russian gas.

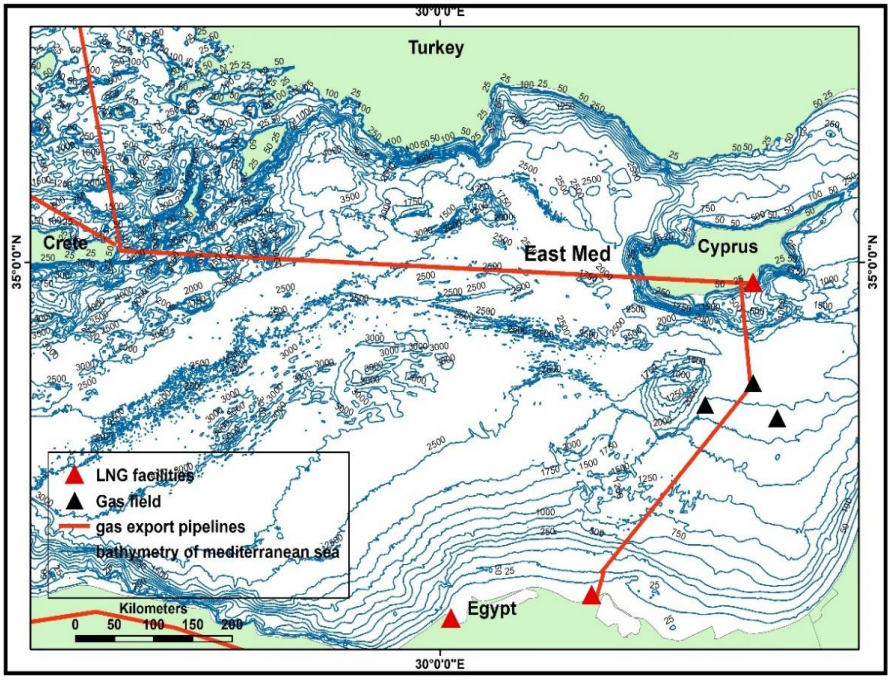


Fig. (13). Bathymetry of the Eastern Mediterranean and East Med gas pipeline, 2019.

Source: Author based on bathymetry data 2019.

The technical study, conducted on behalf of the Natural Gas Supply Corporation of Greece (DEPA) and financed by the EU, confirmed that the project is "technically feasible". Technical feasibility is not the only matter of concern, however. Another challenge is the final cost of gas at destination, which has been projected to range anywhere from $6 per MMBtu to $8 per MMBtu, far higher than the present average Russian gas price ($4.50) that the EU counties are paying.(cyprus-mail.:2017/07/02/). (Mediterranean Energy Regulators, 2015-2019, p.33).

4.3.4. Impact coronavirus (COVID19) on gas market

The Japan Korea Marker (JKM benchmark) gas price dropped down to $3.50/MMBtu early February, its lowest level for more than a decade. Shell is the world's largest LNG trader. In January it reported a 23% drop in its 2019 profits due to low global oil and gas prices. This is also impacting gas prices in Europe, down to $2.70/MMBtu on February 5.2020. Europe is already flooded with gas due to mild

weather lowering demand, but also due to diversion of surplus LNG from Asia (Ellinas, 2020). Henry Hub prices for US gas had already fallen by half over the course of 2019. The coronavirus caused a further 22 % decline in Henry Hub prices from US$2.2 (MMBtu) (10 January 2020) to only US$1.72 per MMBtu (13 April 2020) (European Parliamentary Research Service, 2020, p.1).

4.3.5. Environmental challenges

The Intergovernmental panel on climate change IPCC Special Report on 1.5 ° C states that the available carbon budget for achieving 1.5 ° C will expire between 2030 and 2040, and for 2.0 ° C will expire sometime between 2040 and 2050, with current emissions varying from about 42 Gt CO2/y. Horizon Europe, with its commitment to spend 35 percent of its the planned budget of EUR 100 billion for climate-related activities is a unique opportunity to transform into a true coherent zero-carbon program (European Commission,2018,pp.18-19).

Decarburization of heat processes at high temperatures is likely to be difficult and may take more time, with a 48 bcm decrease in demand for natural gas anticipated in the mid-2030s and most likely in 2040 and 2050. Enhancing energy efficiency through the use of heat pumps and increasing the use of solar and geothermal power are the key mitigation solutions. This represents approximately 48 bcm of demand for natural gas by 2030 in Germany, France, Italy, the UK and Spain. Around 15 bcm of natural gas used as a raw material in manufacturing would take much longer to substitute (Honore, 2019, pp. 40-41).

Therefore, Egypt will be faced international export markets for gas in 2030, which could be drastically different from today, especially in Europe, under the decarburization agenda (kamal, 2019, pp.35, 37).

4.4. Anticipated Changes resulting from Gas trading Hub:

4.4.1. **Change of production regions.** The international bid round for EGAS was also declared for 16 blocks in May 2018, including 13 offshore blocks in the Mediterranean Sea and 3 onshore blocks in the Nile Delta, it is planning to launch an International Bid Round focused on the Mega Mergo project in the western part of the Mediterranean Sea in 2019 (Petroleum Ministry, 2018, p.13). index (1). Egypt planned to develop 11 gas projects with investment around $17.5 billion with production rates 1.9 Bcf/day, it aims to increase production 8

bcf/day by 2022/21. It seeks to develop the petrochemical industry system to maximize the added value of natural gas, which increases 16 times more compared to the use of gas in electricity generation (Ministry of Planning, Follow-up, and Administrative Reform, 2018, p.204). The East Mediterranean countries like Palestine (Gaza), Lebanon and Syria will enter within the gas production regions in the eastern Mediterranean. According to the U.S. geological survey, the potential of undiscovered gas in the Nile delta province is estimated at 6.3 Tcm and of the Levant Basin at 3.5 Tcm (Boustros, 2018, p.10).

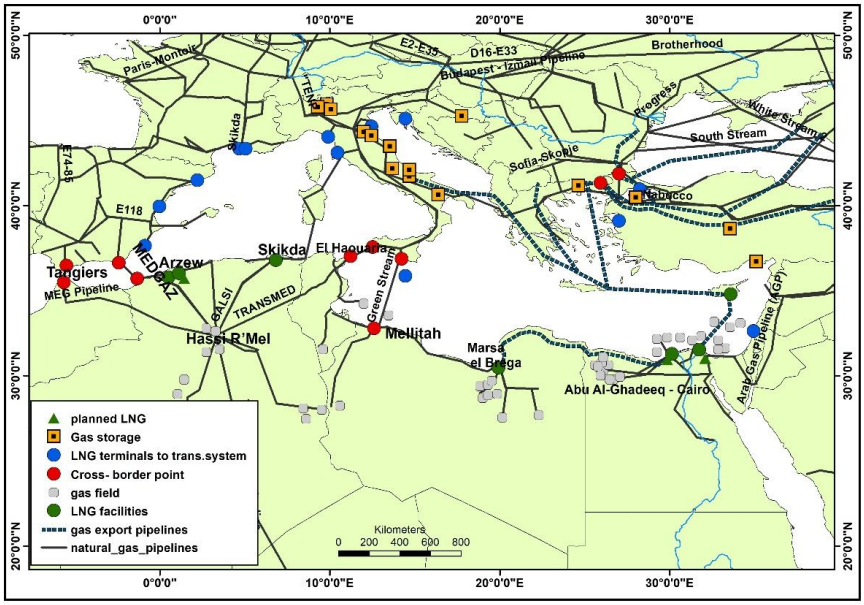


Fig. (14) Potential gas networks and facilities in Mediterranean Region 2020

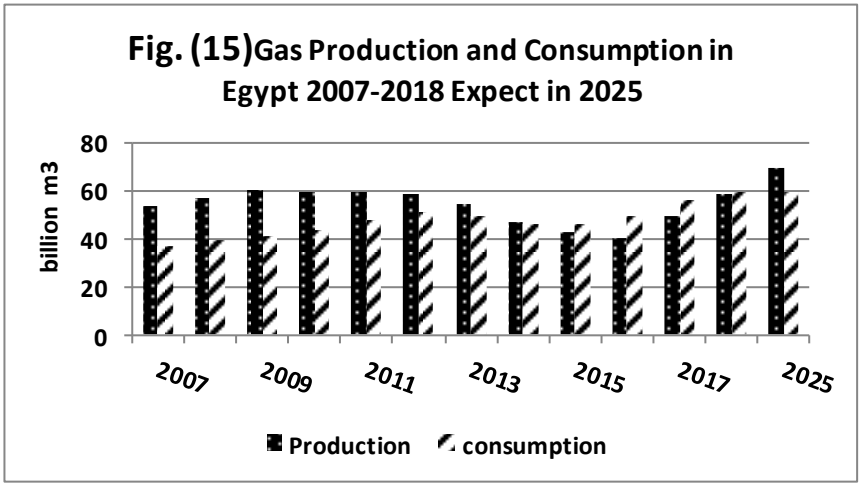
Source: Author based on Entsog map, 2020

4.4.2. **Change of network and facilities**. Gas networks and facilities will be expanded in Egypt, Turkey, Greece, and Italy if pipelines are completed, especially in the Eastern Mediterranean line and liquefaction facilities in Greece and Italy and enter the unit of regasification FRSU in Egypt fig.14. The government completed phases 1&2 of SUMED Terminal for petroleum products trading & storage at Ain Sokhna and

Sonker Platform to receive, store & trade petroleum products at Ain Sokhna. Expansion of Hamra Port at the Mediterranean and upgrade A single buoy mooring SBM and Farm tanks to receive larger tanks (1.0 MMBLL). Upgrade of Sidi Kerir Port to receive and handle Gas Oil (Petroleum Ministry and Minerals Resources, 2018, p.17.). Damietta LNG planned to be 2 trains and Idku LNG to be 6 trains.

4.4.3. Regional Gas market: Egypt, Israel and Cyprus will become one of the most important gas exporting countries, Turkey and Italy will remain the largest gas importers in the Eastern Mediterranean**.** Israel has **the Leviathan and Tamar gas fields** which contain about 900bcm of natural gas, 605b cm of the Leviathan gas field and 318b cm of the Tamar gas field. The security issues related to the EMG pipeline were doubtless a major factor in announcing in January 2019 that construction could begin on a new underwater gas pipeline between Israel and Egypt as early as 2020. (Keenan& Vinter, 2019). There were discussions to send supplies from the Tamar field to the Damietta LNG plant and gas from the Leviathan field to the Idku LNG facilities (Ouki, 2018:29). Texas-based Noble Energy and Israel's Delek Drilling, both operators of these fields, have agreed to supply Delphinus Holdings of Egypt with 85 bcm of gas from these fields over a 15-year period. The deal was worth $ 19.5 billion (Reuters, 2Oct.2019). In Sept. 2018, Egypt and Cyprus signed an agreement for the construction of an underwater pipeline to export natural gas from Aphrodite (130bcm) to Idku (Cyprus-mail. /2018/09/19/)

4.4.4. Gas balance



Source: Author, based on BP, statistical Review of World Energy, 2018, 2019, p.28, 32

Natural gas production and consumption in Egypt vary from 2007 to 2018. **fig.**15. Egypt will become a gas exporter and change gas balance in 2025 because Production increases from recent discoveries, in all three phases of the **West Nile Delta** project is expected to reach up to almost 1.4 billion cubic feet per day (bcf/d), equivalent to about 20% of Egypt's current gas production. All the gas produced will be fed into the national gas grid. The proven reserves of the gas projects from **North Alexandria** are estimated to be 5 (Tcf), while BP acquires 82.75% of these projects. Accordingly, gas production will reach more than 69 billion cubic meters by the year 2025 (Egypt's natural gas market overview, 2019, p.5).

4.4.5. Regional development: If Idku, Damietta and Port Said are chosen for a location of gas trade hub, in these locations will be concentrated the shipping, transportation, storage, distribution, marketing, supply, and trade companies and will be transformed into a regional center for gas trade. Thus, the land use map will change, and the commercial and marketing uses will prevail, thus it will be a center for the production, processing, distribution and marketing of gas in Egypt and east Mediterranean fig. 8,9,10**.**

5.1. Conclusion.

The study concluded by outlining a set of geographical and market requirements that must be met to develop a gas trade Hub in the Eastern Mediterranean. The investigation revealed that the countries of Italy, Egypt, and Turkey are the most ideal locations for the concentration of the gas Hub, respectively.

The paper concluded that Egypt the best location to locating Gas trading Hub in eastern Mediterranean because its strategic location, natural gas reserves, recent discoveries, gas facilities, gas infrastructure, FSRU, interconnection infrastructure, Suez Canal, SUMED pipeline, size of gas market and new Gas market law 2017.

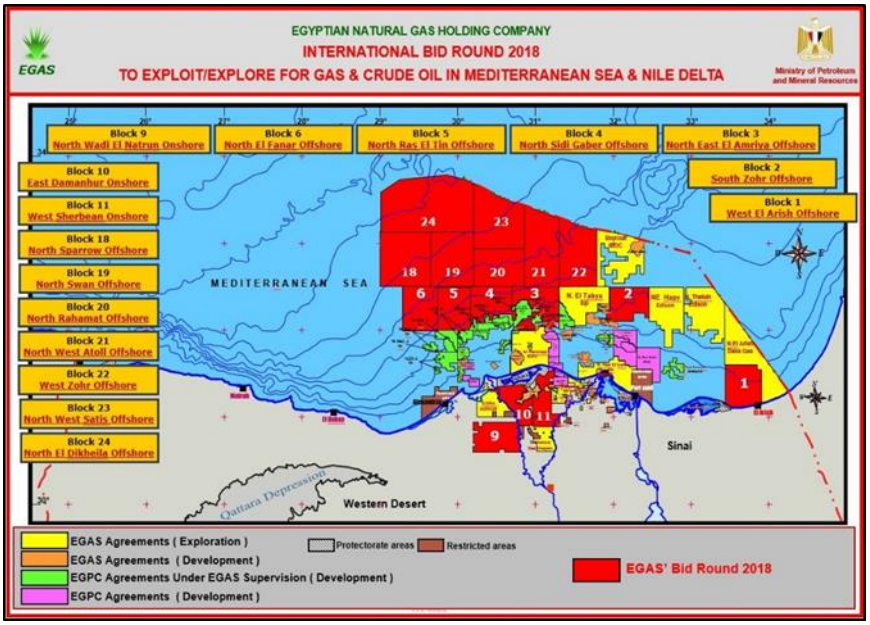
The weights research also revealed that Idku, Damietta, and Port Said are the most important sites in Egypt to localization gas trading hub.

The study concluded that there are economic, political, environmental, and technological obstacles to developing of the gas trade Hub, and that gas production and trade in the eastern Mediterranean will result in significant changes in gas producing regions, infrastructure, networks, markets, and regional development. the land use map will change, and the commercial and marketing uses will prevail, thus it will be a center for the production, processing, distribution, and marketing of gas in Egypt. Selecting sites will be concentrated the shipping, transportation, storage, distribution, marketing, supply, and trade companies

5.2. Recommendation

Future of Gas trading Hub in East Mediterranean Region and Egypt has several options:

- The first option is to extend a pipeline with Cyprus to export gas to Europe.
- The second option is to connect the network of gas pipelines in Egypt with Libya, which is linked to Italy to export gas to Italy and the western and southern Mediterranean countries.
- The third option is to complete and expand the Arab gas pipeline, Egypt, Jordan, Syria, Lebanon, and Turkey, and to link this pipeline with the Iraqi gas pipeline network.
- The fourth option is for Egypt to export liquefied gas from Idku and Damietta plants to Europe and Asia, especially the markets of China and India.
- To increase the gas trading market, the Eastern Mediterranean Forum should be expanded to include Western Mediterranean countries Libya, Tunisia, Algeria, Morocco, France, Spain, and Portugal.
- Settlement of maritime border disputes between nations in the Eastern Mediterranean in accordance with the United Nations Convention on the Law of the Sea and the win-win principle.
- Expansion of natural gas-based petrochemical sectors that add 16 times in value, such as fertilizers, textiles, and methane production, to match the predicted reduction in gas demand in Europe by 2050.



Appendix.1. upstream gas in Egypt 2018
Source: Petroleum Ministry, 2018.

Source: Petroleum Ministry, 2018.

Photo.1. processing gas unit in idku plant
Source: field study,17 Oct. 2020.

photo.2. gas tanks in methanex plant Damietta port Source: field study, 17 oct.2020

Photo.3. coating pipe gas by weight concrete in Petro jet plant, port said.
Source: field study, 17 april.2019

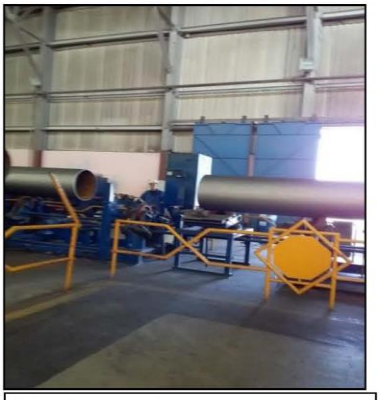


Photo.4. coating pipe gas polyethylene in Petro jet plant, port said.
Source: field study, 17 april.2019

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