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Natural Gas – Fundamentals, Geopolitics and the Way Forward for Resource Monetization

Solon Kassinis*

RÉSUMÉ

Le mot «gaz» a été proposé par le chimiste flamand du 17ème siècle Jan Baptist van Helmont, comme une orthographe phonétique de la prononciation néerlandaise du mot grec «chaos», qui a été utilisé depuis 1538 selon Paracelse pour l'«air». Le gaz naturel est un combustible fossile, gazeux, constitué essentiellement de méthane, mais avec des quantités mineures d'éthane, de propane, de butane et d'hydrocarbures lourds de pentane.

Le gaz naturel gagne de plus en plus de terrain comme le combustible fossile conventionnel «préféré» pour les décennies à venir, en raison de sa caractéristique de combustion plus efficace et plus propre. Il deviendra le prochain combustible fossile le plus utilisé, en remplacement du pétrole.

En vue de renforcer la sécurité de l'approvisionnement énergétique, d'améliorer l'autosuffisance énergétique et pour protéger le rôle géostratégique du pays, des actions systématiques et des plans dans le secteur de l'exploration des hydrocarbures ont été développés à Chypre depuis la dernière décennie. Chypre a officiellement inauguré ses activités d'exploration offshore en 2006 avec l'acquisition de 2-D et des données sismiques 3-D, suivie d'une autre acquisition sismique 2-D, et l'interprétation des données traitées. Deux séries d'octroi des licences ont suivi, en 2007 et 2012, ce qui a abouti à l'octroi de six licences d'exploration offshore au total.

ABSTRACT

The word 'Gas' was proposed by the 17th century Flemish chemist Jan Baptist van Helmont, as a phonetic spelling of his Dutch pronunciation of the Greek word 'chaos', which was used since 1538 after Paracelsus for 'air'.[1] Natural Gas is a gaseous fossil fuel consisting primarily of methane, but with minor quantities of ethane, propane, butane and pentane-heavy hydrocarbons.[2]

Natural Gas is gaining more and more ground as the 'preferred' conventional fossil fuel for the coming decades, due to its characteristically more efficient and cleaner combustion. It has yet to become the next most utilized fossil fuel, replacing oil.

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Aiming to strengthen the security of energy supply, to enhance energy self-sufficiency and to shield the country's geo-strategic role, systematic actions and plans in the hydrocarbon exploration sector have been developed in Cyprus since the past decade. Cyprus officially inaugurated its offshore exploration activities in 2006 with the acquisition of 2-D and some 3-D seismic data, followed by further 2-D seismic acquisition, and interpretation of the processed data. Two licensing rounds followed, in 2007 and 2012, which resulted in the granting of six offshore exploration licenses in total.

The discovery by Noble Energy of substantial quantities of natural gas offshore Cyprus at the end of 2011 constituted a historic development for the island and filled its people with feelings of optimism for the future. The favourable geological conditions offshore Cyprus and the outcomes from the activities of the nearby countries, which drilled for, discovered and produce oil and natural gas, are all encouraging factors for the future.

However, decisions on ways of how to develop the hydrocarbon resources located within the exclusive economic zone of Cyprus, and the ways to harvest the benefits from their exploitation to the maximum possible extent, are not straightforward. What is more, such decisions are complicated by the historically tensioned geopolitical setting of the Eastern Mediterranean region.

This *article* will unfold and discuss all the various interrelated issues regarding the topics on the fundamentals and characteristics of natural gas, the geopolitics, and the way forward for gas monetization, aiming to give firm and straightforward answers on the following:

- How did Cyprus reach this important milestone and which accomplishments have led to the very positive, and promising for the future, results, since its independence in 1960?
- How did Cyprus manage to successfully attract oil and gas companies for exploration?
- What should the targeted way forward in monetizing this divine resource be?
- What sort of infrastructure and commercial structure should be pursued for the monetization of the gas, and what are the risks involved?
- How important is the role of human resources and what measures should be taken towards empowering and educating people?

- What are the prospects for oil discoveries?
- How is bilateral or trilateral cooperation between Cyprus, Greece and Israel in the field of natural gas exploitation expected to unfold?
- What other countries in the East Mediterranean region could come into play?
- What is the role of geopolitics in general, and particularly in enhancing stability and restoring good relations between the states in the Eastern Mediterranean region?
- What should the next steps be towards gas exploitation and monetization?

A fact, that for sure sounds much more realistic today, is that one day the Eastern Mediterranean Region will develop to become a 'second North Sea', thus making it the fourth largest region in hydrocarbons production globally (after Russia, Qatar and the North Sea).

A. The Fundamentals and Characteristics of Natural Gas

Natural Gas, as the name suggests, is a naturally occurring hydrocarbon compound, usually found in the earth as a mineral resource. Natural gas is colorless and odorless (an artificial odor is purposely added to it in order to help detect leakages during pipeline transport), and is lighter than air.[3]

Natural Gas can be commercially produced from conventional, or unconventional, oil fields and natural gas fields. Other types of gas, however, also exist (see below figure[4]).

Figure 1: Town gas vs Blogas vc Landfill gas.

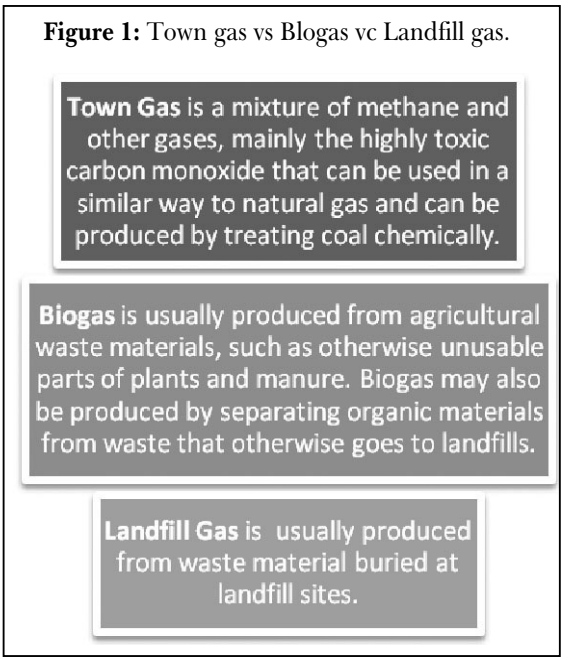
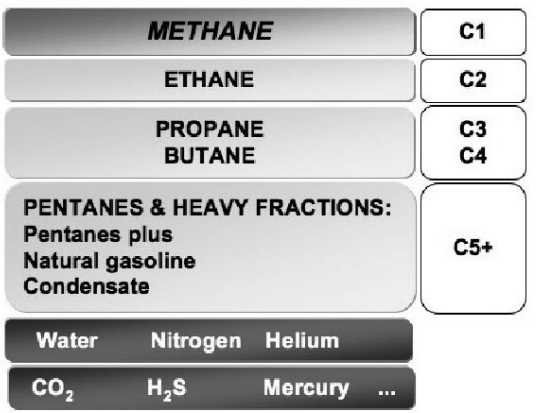


Figure 2: Typical natural gas components (methane is the primary component).



Natural gas is mainly composed of methane (see figure on the right[5]), of the *alkanes group*, which is the simplest hydrocarbon; yet being a fossil fuel it encompasses very many forms and uses today. Associated Gas, Non-Associated Gas, Gas hydrates, Coal Bed Methane (CBM), shale gas, tight sands, are some of its source forms known to date, while the use of natural gas has been extended, from power generation purposes, to petrochemicals production, heating/cooling, cooking and cogeneration of heat and electricity.

Figure 3: The 'Gas Works' facilities.

Gas was used from the 1820s in the Fredonia City of New York for lighting purposes.[6] In Athens (Greece), the production of gas from coal (mainly lignite) began in the late 1850s, with the construction of gas production facilities in an area known as 'Gas Works'[7] (see photo on the right[8]). This gas was used for around 60 years in street lighting, while its use then extended to houses and factories,[9] until the mid-1980s where gas production operations from coal ceased and gas production operations from naphtha began (naphtha was obtained from the crude oil refineries), followed finally by the commencing of natural gas imports from external suppliers in the late 1980s.[10] Nowadays, apart from power

generation and lighting purposes, natural gas is even used in the houses for heating and cooking.

B. The Formation and Existence of Natural Gas

Natural Gas was created after millions of years of thermal anaerobic (i.e. in the absence of air) decomposition and compression of organic matter buried deeply underneath the earth's surface.[11]

The five characteristics that are essential in order for a system of hydrocarbons to exist are as follows:

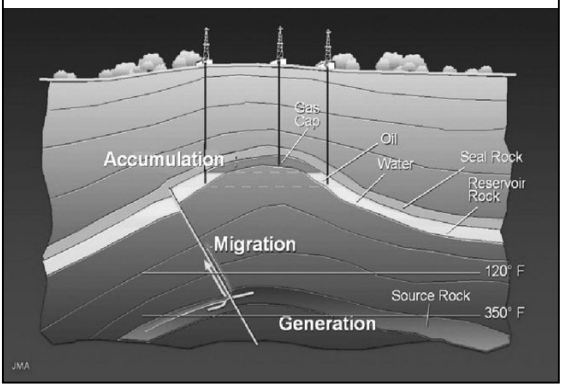
1. SOURCE ROCK (a deep rock within which hydrocarbons are formed/generated from its original organic matter)
2. MIGRATION (the movement of hydrocarbons from the source rock to the reservoir rock over time)
3. RESERVOIR ROCK (a porous, permeable sponge-like rock which retains the hydrocarbons in place)
4. TRAP (the overall geological structure within which hydrocarbons gather)
5. CAP ROCK (an impermeable seal which prevents the hydrocarbons to escape)

Hydrocarbon systems involve complex geological functions as described below[12] and as also shown in the diagram:[13]

– Generation
  - Oil and Gas are formed in Source Rocks

– Migration
  - Oil and Gas move over time from the Source Rock to the Reservoir Rock

Figure 4: The functions of hydrocarbon systems.



- Reservoir Rocks have the following characteristics:
  - Porosity – to store oil and gas
  - Permeability – so that oil and gas may move through the reservoir rock

– Accumulation and Entrapment

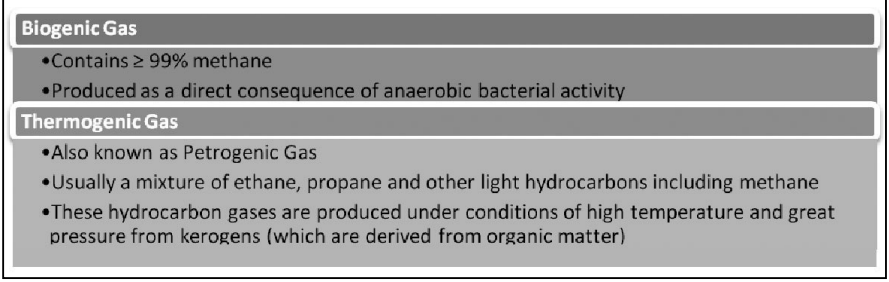
- Oil and Gas are retained in Reservoir Rocks (sedimentary rocks such as limestone or sandstone), which are buried deep below the surface
- A geological trap halts the movement of oil and gas and allows accumulation of entrapped oil and gas

Natural Gas found deeply underneath the earth's surface can be either *Biogenic Gas* or *Thermogenic Gas*, depending on the actual mechanism by which the gas in place was originally formed.[14]

Biogenic gas formation is very identical to biogas generation and thus biogenic gas usually has very pure methane content, while thermogenic gas formation is an indirect consequence of kerogens generation (kerogens are derived from organic matter under conditions of high heat and pressure).[15] The figure that follows provides a summary of the main characteristics of each formation mechanism.[16]

Natural gas can exist either as 'dry gas', which is pure methane, and 'wet gas', which is mainly methane together with heavier hydrocarbons in varying proportions.[17]

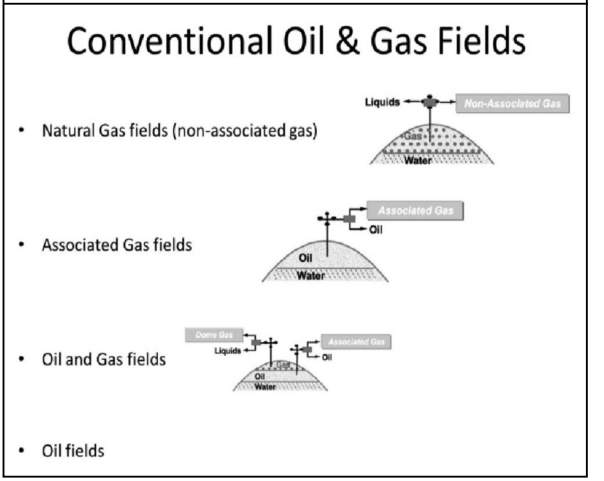
Figure 5: Blogenic Gas. vs Thermogenic Gas.



The presence of inert components in natural gas, such as nitrogen and carbon dioxide, tends to reduce the calorific value of the gas. On the other hand, hydrogen sulfide, when present in natural gas, must be removed during initial processing because of its toxicity and corrosiveness. The presence of

hydrogen sulfide accounts for the 'sourness' of natural gas (natural gas with the absence of hydrogen sulfide is called 'sweet' gas), while the presence of significant quantities of acidic gasses, such as hydrogen sulfide or carbon dioxide, make the gas 'acidic'.[18]

Figure 6: Conventional Oil & Gas Fields - Configurations.



Gas fields with an appreciable proportion of heavier hydrocarbons are known as *condensate* deposits ('condensates'). While wet natural gas and condensates are found near to, or in combination with, oil deposits, dry gas is usually found alone in individual gas fields. This is due to the fact that most of the dried natural gas derives from terrestrial plants.

There is also a distinction between 'associated gas', which is natural gas associated with crude oil, and 'non-associated gas', which is generated individually (see figure on the right[19]).

In the case of 'associated gas', natural gas is dissolved in the crude oil and released during production due to the pressure relief (from a high pressure inside the underground reservoir to a lower pressure, close to atmospheric, at the surface). If crude oil is supersaturated, then part of the gas migrates upwards and forms a gas dome, which under certain conditions may be exploitable.

The main components of natural gas deposits are often related with crude oil, particularly as to their formation. Oil and gas are often found in the same geological strata of a region. 'Dry gas', which is mainly a product of carbonization, can also be found next to oilfields, as the majority of natural gas fields around the world is related with oil deposits.

The recovery of oil and gas from the hydrocarbon fields can be done through various mechanisms. In most cases, and for newly producing fields, the

reservoir pressure causes the fluid (oil or gas) to rise to the surface when a borehole is drilled down to the Reservoir Rock. This reservoir pressure diminishes along with production and therefore, at some point, other methods (usually physical and chemical) must be used to recover the rest of the hydrocarbons in place (such methods can be fluid injection – water or CO2, fracking, injection of chemicals etc.).

The portion of hydrocarbons that can be brought to the surface is called 'recoverable'. The level of recoverable hydrocarbons depends on the physical properties of the reservoir and the recoverability is categorized by the probability of recovery – 10% for *Possible Reserves*, 50% for *Probable Reserves*, 90% for *Proved Reserves*.

C. The Importance and Marketing/Trading of Natural Gas

Natural Gas is gaining more and more ground as the 'preferred' conventional fossil fuel for the coming decades, due to its characteristically more efficient and cleaner combustion. It has yet to become the next most utilized fossil fuel, replacing oil. The whole (integrated) natural gas market *value chain* is shown in the figure right below.[20]

Although being a gas fuel rather than a liquid fuel (such as oil) makes it lighter, and therefore it has a low energy density, which in turn makes its

Figure 7: The natural gas market value chain.

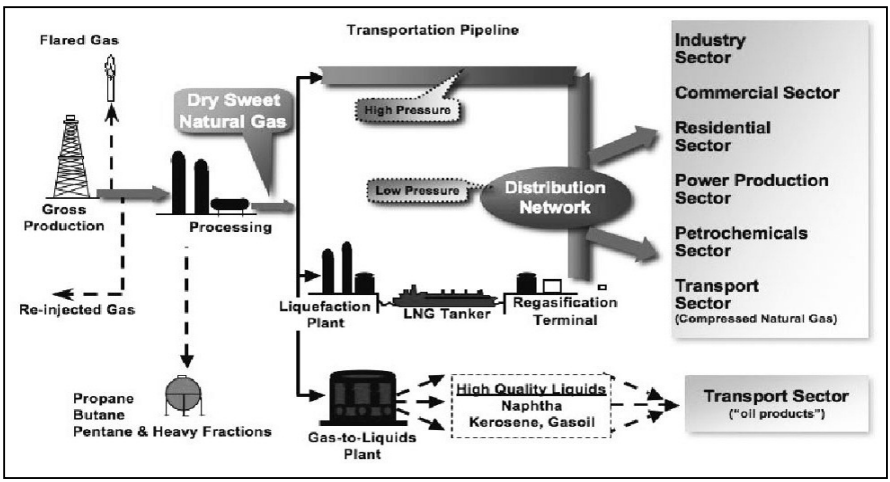
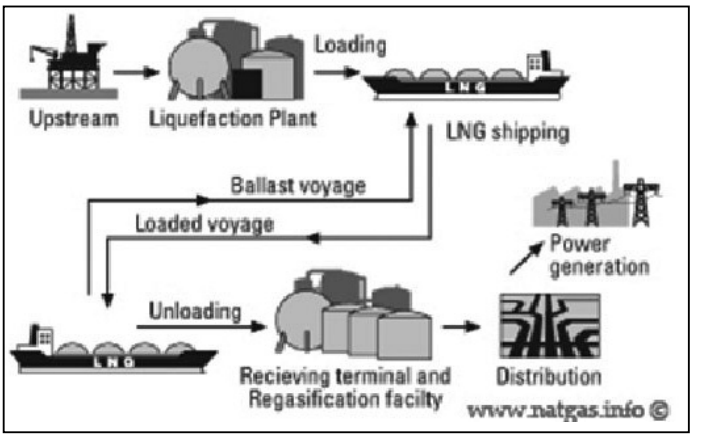


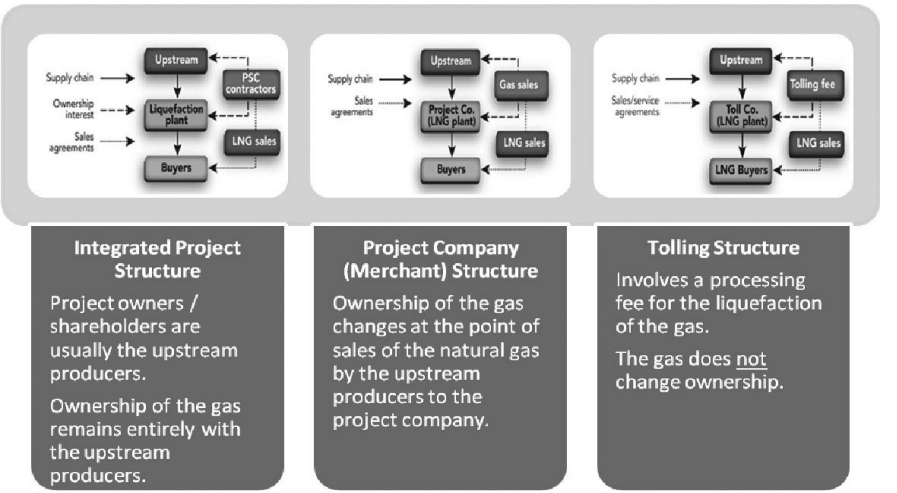
Figure 8: The LNG chain.



transportation and storage more costly per energy content as compared to oil, its distinct characteristics give to it many more advantages (in addition to the ones referred to above) – mainly versatility and robustness in its use, as well as safety and flexibility during its transport (this is especially true for LNG which is contained and transported at atmospheric pressure by special marine tankers).

Gas fields in remote areas are utilizable only if the market price makes the processing and export of natural gas economically feasible. A common concept (in the case of large volumes and large distances) is the liquefaction of natural

Figure 9: The three main commercial structure models for Liquefaction Plants.



gas to produce LNG (Liquefied Natural Gas) and its subsequent export by special marine tankers to consumer countries (the *LNG chain* is shown in the figure on the right[21]).

Three main commercial structures exist regarding a Liquefaction Plant and these govern the way that the project is set-up. These three main commercial models are presented below.[22]

The participants in a Liquefaction Plant project may include any or a combination of the following (depending on the shareholding/ownership structure): Governments (either directly or through their National Oil Companies), International Oil Companies, Upstream producers, LNG off-takers, LNG operators, third party investors. In addition, there are other important parameters to consider when evaluating the financial viability of a Liquefaction Plant, such as the tolling fee (if tolling structure is chosen), shipping cost, gas netback price, inflations, capital costs, operating costs, LNG prices, financing plan, risks, commercial structure etc.

Crude oil, similar to gold and other goods, is traded today as a *commodity*, and is available through spot markets on a global basis. On the other hand, the spot price and trading of natural gas differs between regions and continents, while gas supplies (either in natural form or as LNG) are carried out through long-term Sales & Purchase Agreements (SPAs).

D. Ways of Utilizing and Monetizing Natural Gas

As mentioned previously, natural gas can have many uses – from large scale power generation and industrial cogeneration, to petrochemicals production and even to small scale domestic heating and cooking. The uses of natural gas by sector are as follows:

- **Industrial Sector**
  - Power generation
  - Cogeneration of power and heat
  - Heating
  - Raw material for the production of petrochemicals (such as methanol, ammonia etc.)
- **Commercial Sector**
  - Central heating
  - Heating/Cooling
  - Hot water production

– **Transport Sector** ○ Cars ○ Trucks ○ Busses ○ Ships	– **Domestic Sector** ○ Mainly for central heating and cooking

In addition, natural gas can be monetized (exported) in very many ways, the main ones being the following (see also figure that follows[23]):

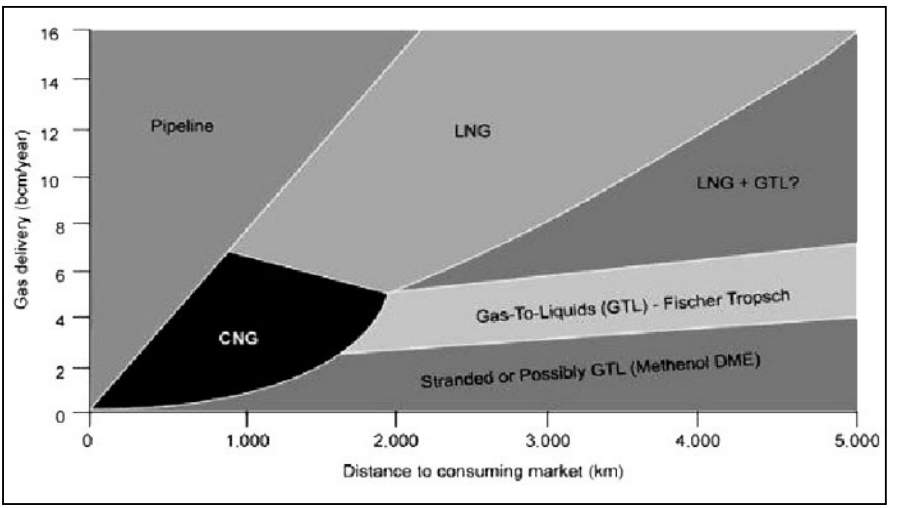
– Liquefied Natural Gas (LNG)
  - Small-scale Liquefaction Plants (small-scale LNG)
  - Large Scale onshore Liquefaction Plants (LNG Plants)
  - Floating Liquefaction Plants (FLNG)

– Petrochemicals
  - Petrochemical Plants (using natural gas as a raw material for the production of petrochemical products and their subsequent export)
  - Natural Gas Liquids (NGLs)

– Gas-to-Liquids (GTL)

– Compressed Natural Gas (CNG)
  - Pipeline CNG

Figure 10: Chart with monetizing options for natural gas fields.



- Marine CNG (this technology is not yet commercially available)

– Electricity (using natural gas as a fuel for power generation and subsequently exporting the produced electricity).

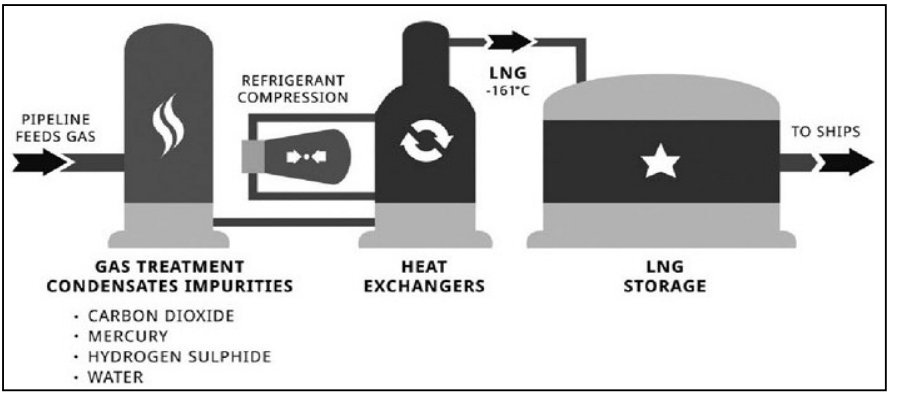
E. Natural Gas Operations & Processes – Purification, Liquefaction, Regasification, Storage and Petrochemicals Production

Prior to any further use/processing, raw natural gas produced by the upstream oil/gas fields needs to be treated in order to purify it. This process occurs at a Gas Processing Plant (or Gas Plant as is also called) and mainly involves the separation of the gas from any water and condensates (i.e. heavy hydrocarbons, that have condensed out of the vapour phase during transport) using a three-phase separator followed by water treatment and condensate stabilization; the subsequent removal of any acidic or corrosive gasses by contacting the dry gas with *amine absorbers*; its drying using *glycol dehydration towers* to remove any water vapour in solution with the gas; and finally the removal of the natural gas liquids through cooling/expanding the gas, and *fractionation* of the liquids in a series of distillation columns to purify each NGL and the methane gas.

Liquefied Natural Gas (LNG) is natural gas (predominantly methane) that has been converted into liquid form for ease of storage and transport,[24] by cooling it down to -161°C, through a series of *refrigeration cycles*. LNG is an odourless, colourless, non-toxic and non-corrosive liquid that can float on water (i.e. it is less dense than water).[25] LNG has the great advantage that it takes up about 1/600th of the volume of natural gas in the gaseous state;[26] therefore it can be stored and transported over long distances and in large volumes more practically and economically. The main stages that take place in a liquefaction plant for the production of LNG are as follows (see also figure that follows[27]):

1. Pre-treatment (to remove impurities and water)
2. Pre-cooling (to remove any condensates)
3. Liquefaction (by a series of refrigeration cycles to liquefy the gas)
4. Storage (maintain the LNG until needed) and loading onto LNG carriers (to transport/export the LNG)

Figure 11: The Natural Gas liquefaction process.



Following regasification at a Regas Terminal, LNG is converted back to natural gas and fed into the *transmission system* (for delivery to the power generation plants and other large industrial units), and then into the *distribution network* (for distribution to the commercial, domestic and transport sectors). The main steps that take place at a Regas Terminal are as follows:

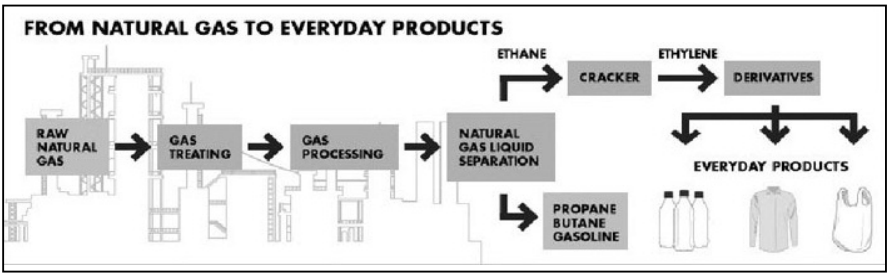
1. Storage (maintain the LNG until needed)
2. Pumping the LNG out of the tanks and into the gas send-out system
3. Passing the LNG through a re-condenser unit (to liquefy any boil-off gas collected from LNG vaporizing inside the tanks; thus balancing the process)
4. Pumping the LNG through a series of heat exchangers (usually Open Rack Vaporizers – ORVs, which use seawater as the heating medium) to vaporize it back to gas and heat it up to atmospheric temperature
5. Compressing the gas and feeding it to the transmission system

Gas consumption, in most cases, is not regular throughout the year, and thus storage of gas is therefore essential in order to enable matching of supply with demand. Natural gas can be temporarily stored in its natural form (as an artificial gas deposit) in natural underground reservoirs, such as *depleted gas* reservoirs, *aquifer* reservoirs, and *salt cavern* reservoirs. Alternatively, natural gas can be stored in its liquid form (i.e. as LNG) in so called *full containment tanks*, but in this case it will need to be liquefied before storage and regasified before use.

Petrochemicals are produced in Petrochemical Plants through a series of processes (chemical reactions and purification methods) that turn the feedstock (natural gas) into chemical or fuel products (petrochemicals). Most final products can be produced directly or indirectly from their preceding compounds (see figure below[28]).

The most important petrochemicals are:

Figure 12: The petrochemicals production process.



– Lower or lighter alkenes (olefins): e.g. ethylene, propylene and butadiene

– Aromatics: benzene, toluene, xylene, dimethyl ether (DME)

– Ammonia, methanol, synthesis gas (Carbon Monoxide - CO & Hydrogen - H2)

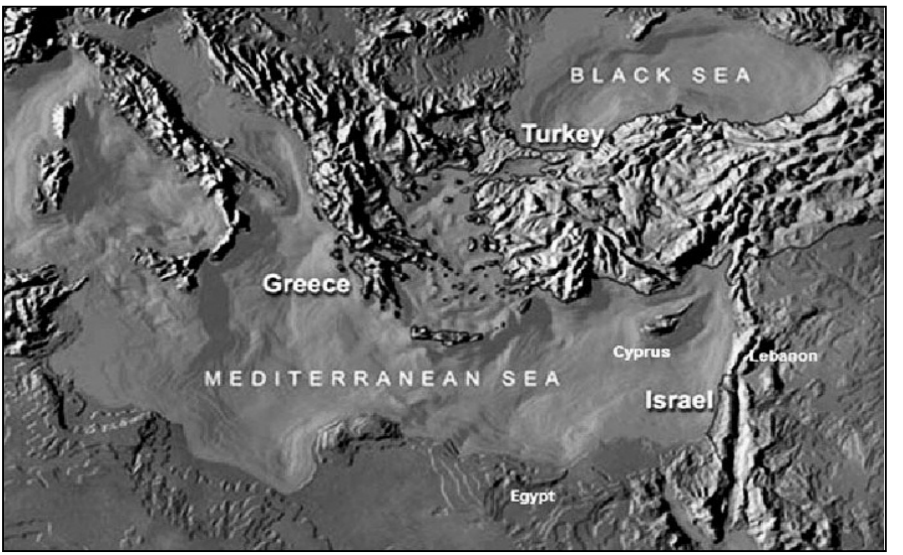
Alternatively, natural gas can be converted into liquid products via a process called Gas to Liquids (GTL); these liquid products, together with the NGLs recovered from the initial processing and the liquefaction of the gas, can be used as fuels, mainly for the transportation sector.

F. The Geopolitics of Natural Gas in the Eastern Mediterranean Region

The Eastern Mediterranean Region (map shown in the picture that follows[29]) has been a hydrocarbons producer for many decades. Especially in Egypt, but also in Israel (although at a much lower level and only for gas), hydrocarbon production facilities have been in operation for many years.

Moreover, Palestine has an offshore gas field located at 30km off the coast of the Gaza Strip, pending development.

Figure 13: Map of the Eastern Mediterranean Region.



Cyprus only joined lately, with many ongoing hydrocarbon exploration activities, while Lebanon is moving with the necessary steps towards the launching of hydrocarbon exploration activities in its EEZ.

Greece, which has been producing oil for some years, seems to be now following Cyprus' model and is also expected to launch a new round of hydrocarbon exploration and exploitation activities within its EEZ, following a successful 'open door' procedure for three areas with promising geological prospects for hydrocarbons.

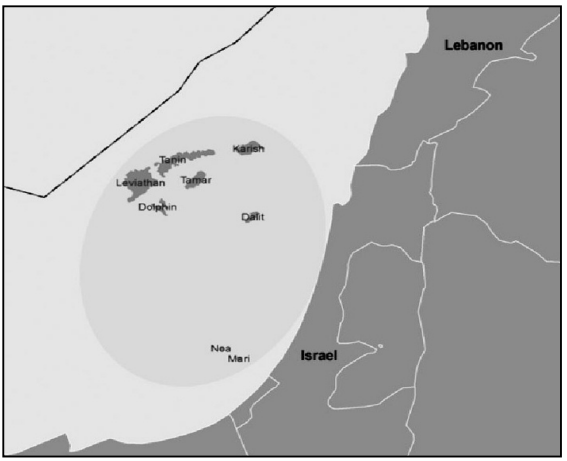
From the above mentioned facts, it can be deduced that currently, the three main players in the region are Cyprus, Greece and Israel. A trilateral regional cooperation between these three states regarding hydrocarbon development and exploitation can therefore be of a great benefit for the Eastern Mediterranean Region discoveries. Such cooperation can also set the baseline, for a future extension towards Egypt, Lebanon and possibly Palestine, which also have an important role to play in the Eastern Mediterranean Region. Overall, the Eastern Mediterranean Region presents many opportunities, in parallel with some challenges, which can be offset as the facts today reveal (see figure below).

G. The Role of Israeli Natural Gas in the Eastern Mediterranean Region

Figure 14: Opportunities, Challenges and Facts for the Eastern Mediterranean Region.

Opportunities	Challenges	Facts
•Promising regional geological background •Big hydrocarbon discoveries in the region •Many attractive major "plays" have been identified •Market with large potential for oil and gas trading •Located at the crossroads of international energy routes	•Historically tensioned geopolitical setting •Unstable political scene •Deep & Ultra Deep Operations	•Hydrocarbon activities can serve as a catalyst towards cooperation and stability in the region •New deep water technologies decrease the risk of the oil companies •High oil prices and increased gas demand secure the commerciality of the hydrocarbon discoveries

Figure 15: Cas Fields discovered offshore Israel.



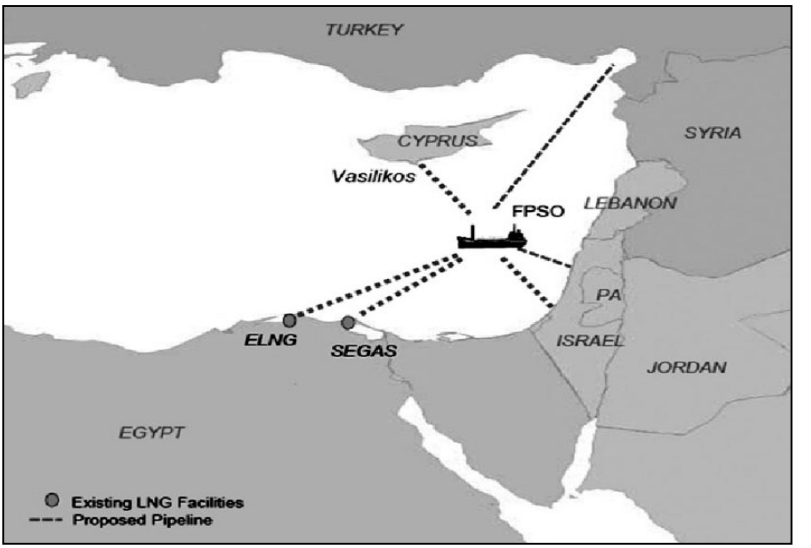
Israel discovered substantial quantities of natural gas within its Exclusive Economic Zone (EEZ). In the last six years, a series of successful exploration wells offshore Israel has resulted in the discovery of approximately 35 trillion cubic feet (tcf) of gas resources (see figure on the right[30]).

Gas production from the Tamar field (10 tcf of gas resources) began in March 2013, just over four years from its discovery. The target for initial production from the Leviathan field (reserves estimate was increased in 2013 to 21.93 tcf, or 620 billion cubic metres, from 18.91 tcf) is 2017.[31]

The Israeli Government has already reached a decision to export 40% of its current gas resources as reported above.

Part of Israel's gas resources will be utilized for domestic market needs (Israeli domestic demand growth expectation has increased to 17%). On the gas export side, various regional market opportunities are being evaluated by Noble Energy

Figure 16: Regional Market Opportunities evaluated by Noble Energy.



Inc.; these include the following options[32] (see also figure on the right[33]):

– power and industrial needs in Jordan
– existing liquefaction facilities in Egypt
– domestic market in Cyprus
– liquefaction plant in Cyprus
– floating LNG
– pipeline to Turkey.

H. The Role of Greece in the Eastern Mediterranean Region

Between the 1960s and mid-1970s, around 40 exploration drillings took place by various international companies in both onshore and offshore locations in Greece. As a result, oil and gas were discovered in two different fields, offshore Greece.[34] Various other exploration attempts followed (both seismic exploration and exploration drilling), leading to the discovery of oil in the offshore Katakolo area in North-West Peloponnese, gas in Epanomi, an area adjacent to Thessaloniki in Northern Greece, and, in some instances, biogenic gas accumulations.[35]

There has been a 15 year break in hydrocarbon exploration in Greece, since most seismic data acquisition and drilling occurred between 1977 and 1987. This activity identified some plays, drilling made one discovery and several wells with shows, but nothing commercial was then revealed.[36]

In 1996 the first International Licensing Round, involving 6 concession areas, was carried out, and as a result, 4 licenses were finally granted for the areas in North-West Peloponnese and Ioannina to Enterprise Oil and for the areas of Aitoloakarnania and off-shore Western Patraikos Gulf to Triton Ltd.[37] The surveys within these areas failed to deliver results and well drilling did not reach the depth envisaged by the original agreements.[38]

In 2012/2013, PGS acquired MultiClient 2-D (MC2D) seismic data in the Western and Southern Greece for the Hellenic

Figure 17: Seismic data acquisition lines from the PGS survey in Greece in 2012/2013.

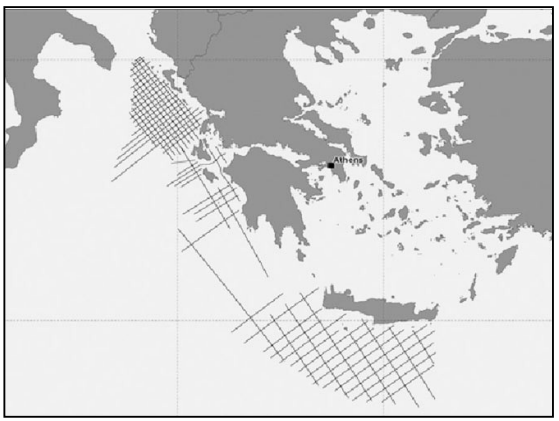
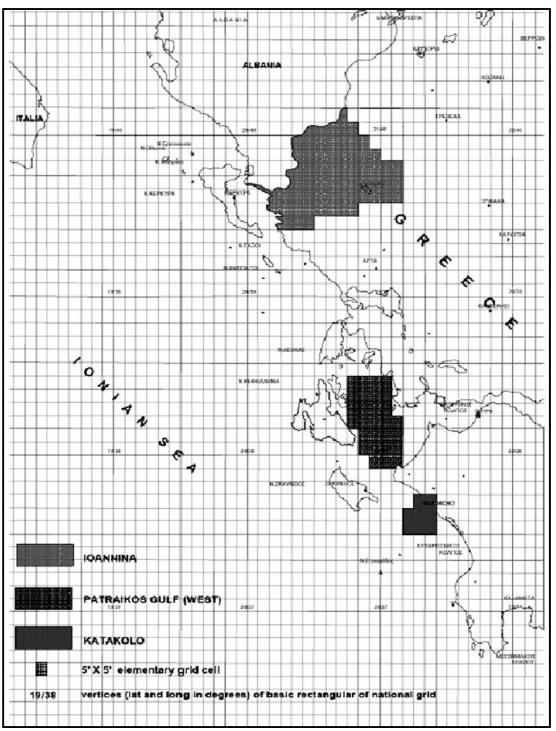
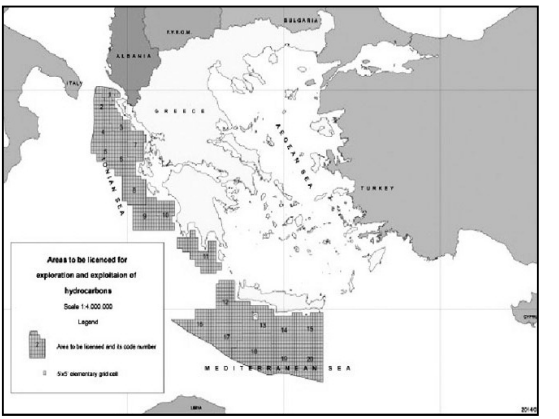


Figure 18: Areas offered through the 'open door' procedure in Greece.



Republic (Ministry of Environment, Energy and Climate Change).

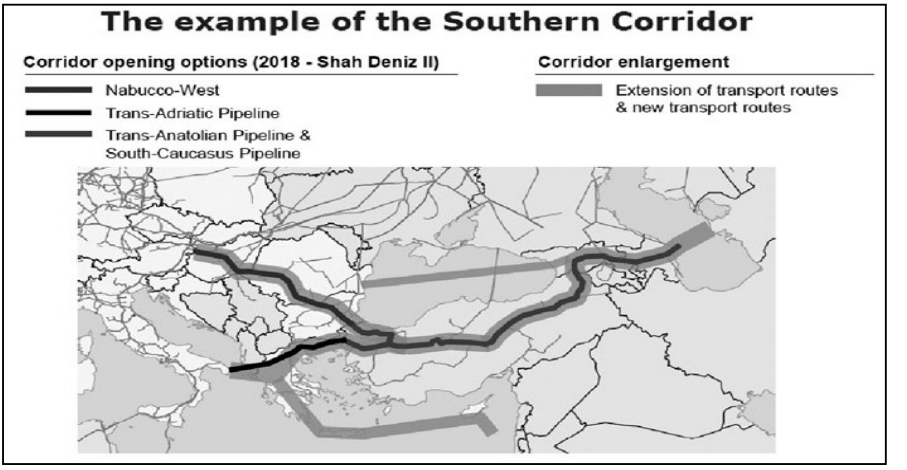
Figure 19: Map with Offshore Blocks on offer in Greece.



The program comprised of 12,500km new data acquisition using *GeoStreamer* technology, with 6,000km vintage data re-processing that was combined into a regional interpretation.[39] The seismic data acquisition (see previous figure),[40] which also included marine gravity and magnetic data acquisition, was completed within 2013 and the full processing of the data was completed in early January 2014.[41]

Regarding the 'open door' procedure, which was launched in 2012, the Greek Government granted three concession agreements in May 2014 (after around 29 months of evaluation of the proposals received), for the areas of offshore Katakolo, offshore Patraikos Gulf (West) and onshore Ioannina (see figure on the right[42]).

Figure 20: The proposed European Southern Corridor.



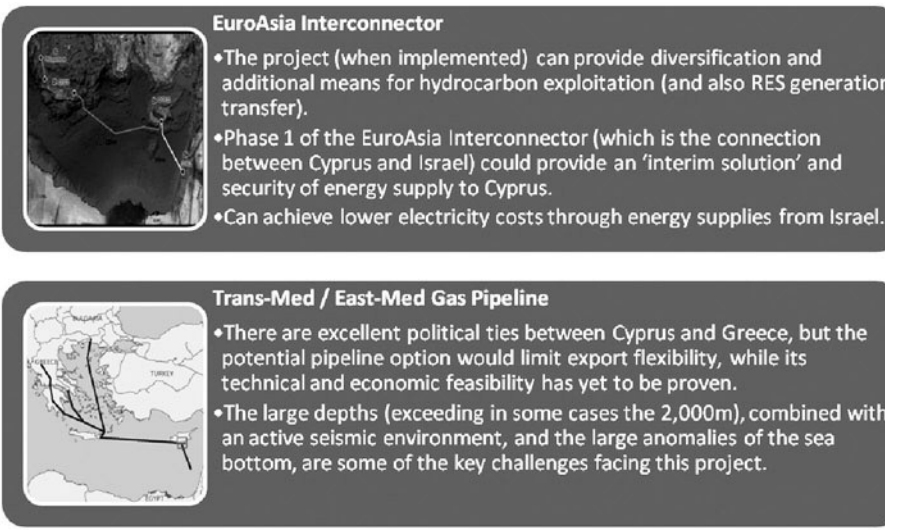
Following the great success during a special information and promotion event held in London in early July 2014 and the interest shown by international oil and gas companies, a second International Licensing Round was launched on the 31st of July 2014, with 20 offshore exploration blocks on offer in the Ionian Sea and the area south and west of Crete (see map below).[43] In addition, an Individual Express of Interest was announced regarding 3 onshore areas in Western Greece.[44]

I. Bilateral Projects of Common Interest between Cyprus and Greece

Cyprus and Greece are both included in the European Southern Corridor for Gas and Electricity, with two jointly proposed projects of common interest. Through these bilateral projects of common interest of the Southern Corridor, Greece can become a major transit country for the supply of Eastern Mediterranean gas to Europe.

In addition, through these projects, Cyprus can have the role of a central and integrated energy hub for gas exports from the Eastern Mediterranean Region to both Europe and the Far East.

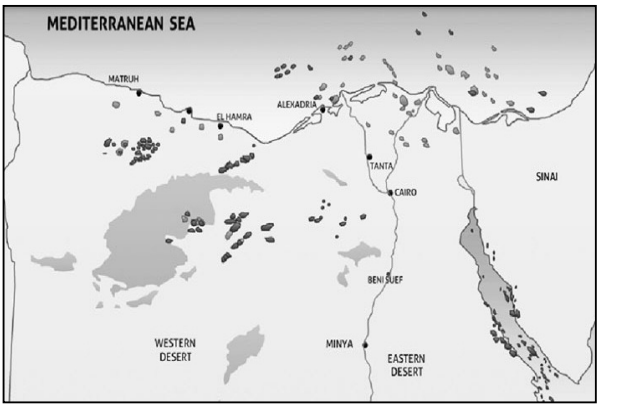
Figure 21: Bilateral projects of common interest between Cyprus and Greece.



The example of the European Southern Corridor is shown in the figure that follows.[45]

The two bilateral projects jointly submitted within the context of the Southern Corridor by Cyprus and Greece (see figure that follows[46]), are the *EuroAsia Interconnector*, a submarine cable for transmission of electricity between Israel - Cyprus - Crete - Greece (mainland), and the *Trans-Med / East-Med Gas Pipeline*, a subsea gas transmission pipeline between the Levantine (offshore)-Cyprus-Crete-Greece (mainland). Both projects can provide diversification and additional means for hydrocarbon exploitation. In addition, the *EuroAsia Interconnector* project could provide an 'interim solution' to Cyprus and security of energy supply to Cyprus, Greece and Israel.

Figure 22: Map showing existing discoveries in Egypt-oil and gas.



J. The Facts about Egypt and Lebanon

Egypt had proven gas reserves of 65.2 trillion cubic feet (tcf) at the end of 2013.[47] The map on the right shows the locations of the existing oil and gas discoveries in Egypt.[48]

The total gas production from all Egyptian fields during the year 2012 reached 2.27 tcf. However, due to the increased internal consumption, the two liquefaction plants (namely Damieta & Idku LNG Plants) have been idled. In addition, there was a continuous political instability in the country, which in turn seems to have discouraged investments in oil and gas activities.

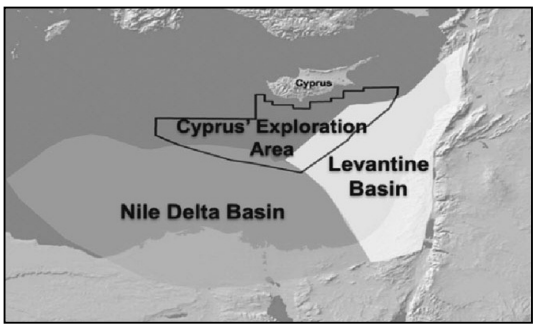
The newly inaugurated Government is hoped to restore political and social stability in the country, but still more investments will be needed for the oil and gas industry in Egypt to flourish once again.

As far as Lebanon is concerned, it is worth highlighting the following statement made in 2013 by the Lebanese Minister of Energy: "*Preliminary surveys of Lebanese offshore fields show reserves of 30 tcf of natural gas and 660 million bbl of oil*".[49] The launching of the 1st Licensing Round offshore Lebanon is expected by the end of 2014, while there has been a large interest from international oil companies who have bought the relevant seismic data.

K. Hydrocarbon Prospectivity in the Eastern Mediterranean Region

According to the USGS 2010 estimates, the Nile Delta Basin had 1.76 billion bbl of undiscovered oil and 223 tcf of undiscovered natural gas reserves, while the Levantine Basin had 1.68 billion bbl of undiscovered oil and 122 tcf of undiscovered natural gas reserves[50] (geological regions shown in the map below).

Figure 23: The Nile Delta Basin and the Levantine Basin.



Updated Noble Energy Inc. estimates (announced as highlights of the 2013 Analyst Conference held in Houston, Texas on Dec 17, 2013):[51]

> *In the Eastern Mediterranean, discovered gross resources have grown to approximately 40 trillion cubic feet of natural gas…. Significant exploration potential remains on the Company's acreage position in the Eastern Mediterranean, with approximately 3 billion barrels of gross unrisked oil potential in the deep Mesozoic play in both Cyprus and Israel and four trillion cubic feet gross of natural gas potential in Cyprus. Current plans are to resume exploration drilling in the Eastern Mediterranean in late 2014 or early 2015.*

L. The Historical Case of Cyprus in Hydrocarbon Exploration

Early onshore hydrocarbon exploration attempts in Cyprus have been carried out by various foreign companies between the period of 1938 and 1970.

Between 1938 and 1949, a series of onshore geophysical surveys were carried out, while for the rest of the period up to 1970 various onshore exploration wells have been drilled between long time intervals.[52] These efforts had no success in finding oil or gas, and were followed in 1975 by an 8,000 km 2-D offshore seismic survey in the Eastern Mediterranean conducted by Sefel Geophysical Ltd (in collaboration with Delta Exploration Inc.) and in 1985-1987 by studies on the seabed bathymetry, stratigraphy, lithology, sediments etc. led by the Soviet Academy of Sciences (in collaboration with the Geological Survey Department of Cyprus).[53]

In 1999, Spectrum Energy & Information Technology Ltd carried out a study on the seismic lines and reprocessed the seismic data acquired in 1975 by Sefel Geophysical Ltd, while in 2000 the same company conducted an offshore 2-D seismic survey of 12,300 line-km in the greater South-Eastern Mediterranean region.[54]

Figure 24: Exclusive Economic Zones' Median Lines between Cyprus and Egypt, Lebanon, Israel.

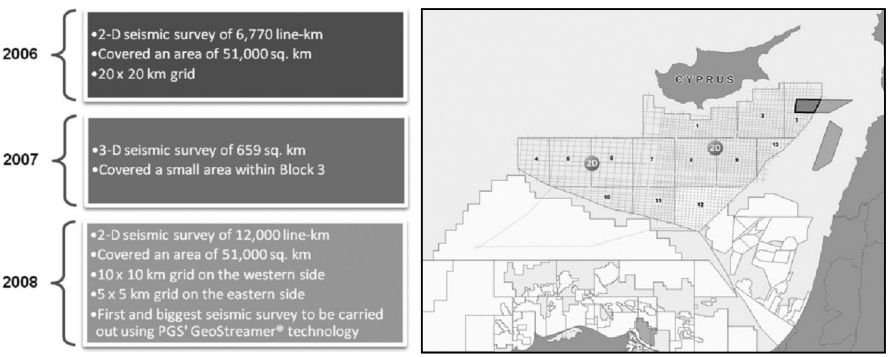
Cyprus, exercising its sovereign rights, as derived from the United Nations Convention on the Law of the Sea (UNCLOS '82), has signed in 2003 its first agreement regarding the delimitation of the exclusive economic zone with the Arab Republic of Egypt. Likewise, agreements with the Republic of Lebanon and the State of Israel followed in 2007 and 2010, respectively (see figure on the right[55]).

Such actions were of paramount importance in attracting oil and gas companies to invest in the exploration activities offshore Cyprus, as well as for strengthening further the ties of good cooperation with the neighbouring countries of Cyprus, especially Israel, but also Lebanon and Egypt.

Cyprus officially inaugurated its offshore exploration activities in 2006 with the acquisition of 2-D and some 3-D seismic data, followed by further 2-D seismic data acquisition in 2008, and subsequent interpretation of the processed

data (see details that follow, on modern seismic surveys conducted by PGS offshore Cyprus[56]). These seismic surveys were the basis for the preparation of the relevant seismic data interpretation reports that followed each survey and accompanied the seismic data set that was acquired.

Figure 25: Seismic surveys acquired offshore Cyprus by PGS between 2006 and 2008, and relevant grid map showing these seismic surveys.



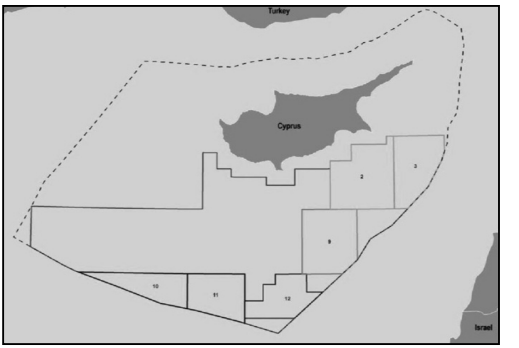
In early 2007, Cyprus proceeded with its first hydrocarbon licensing round with a total of eleven offshore blocks on offer, attracting three applications from two applicants. Within this context, one hydrocarbon exploration license was awarded, following negotiations, to Noble Energy International on 24 October 2008, for Block 12 (a relevant Production Sharing Contract was also signed on that date). Following all the necessary preparatory work and data assessment, Noble Energy International proceeded with drilling its first exploratory well in September 2011.

The breakthrough for Cyprus came in December 2011 when Noble Energy announced, after the first exploration well, that a discovery of natural gas (7 tcf gross mean estimated resources) had been made in Cyprus' exclusive economic zone Block 12 (the deposit was named 'Aphrodite'). The appraisal well of that discovery that followed in 2013 resulted in an updated estimate of approximately 5 tcf mean gross resources of natural gas. The results that will derive from the evaluation of the data in 'Ishai' (an area adjacent to Block 12, within the Israeli EEZ), obtained from an exploration well drilled in early 2013, will determine Noble Energy's next steps which are required for further appraisal of the gas discovery. Regardless of the procedure needed for

declaring commerciality of the gas deposits in the 'Aphrodite' discovery, Noble Energy estimates that production can commence within 38 months from the *final investment decision*. Additionally, Noble Energy is currently planning to explore other promising geological formations within Block 12, with a substantial possibility for new discoveries.

The success in Block 12, in addition to the clear and transparent regime that was established in full harmonization with the relevant European Directives, caught the attention of the international oil and gas companies around the globe and created a huge interest in Cyprus' second hydrocarbon licensing round held in 2012, with 33 applications from 15 companies/consortia. After evaluation of the applications submitted, a hydrocarbon exploration license for each one of the Blocks 2, 3 and 9 was granted to Eni/Kogas on the 24th of January 2013, while on the 6th of February 2013, a hydrocarbon exploration license was awarded to Total, for each one of the Blocks 10 and 11 (see relevant map with licensed blocks, on the right[57]).

Figure 26: Licensed blocks for Hydrocarbon Exploration offshore Cyprus.



Relevant Exploration and Production Sharing Contracts (EPSCs) were also signed with the two abovementioned licensees, for each one of the awarded blocks. Through these contracts, the two licensees are committed to execute an 'aggressive' exploration work program for each one of the awarded blocks, acquiring a large amount of geophysical data and drilling at least six exploration wells in total during the first three years.

M. The Role of Cyprus in the Eastern Mediterranean Region

The abovementioned developments testify that the oil & gas sector can be a new booming industry in Cyprus, as the country has already attracted worldwide attention and serious international investment prospects exist. The discovery of substantial quantities of natural gas, in combination with the potential utilization of other gas deposits and future gas findings in the area,

opens up new perspectives and new impetus to the role of Cyprus in the global energy map and the European energy market.

To fully grasp this great opportunity, Cyprus still needs to swiftly proceed with the planning and development of the energy infrastructure and facilities required for the exploitation of natural gas reserves, such as the construction of the subsea gas pipeline for the transfer of natural gas to the Cyprus shore, in parallel with the establishment of a natural gas liquefaction plant for the production and subsequent export of LNG (see relevant sketch on the right[58]).

Figure 27: Artist's impression of the Vasilikos LNG Plant.

Such an initiative by Cyprus, which is a member of the European Union strategically located in the Eastern Mediterranean Region, can significantly contribute to the efforts towards establishing secure natural gas resources and diversified energy corridors for the EU and beyond. Once Cyprus is successful in establishing the necessary infrastructure in the region for hydrocarbons operations and exports, this will then stimulate additional oil and gas exploration and production activities across the Eastern Mediterranean, leading to the evolution of the oil and gas industry in the area.

The construction of the Cyprus LNG Plant will be by far the largest investment in the island's history and can therefore constitute the key driver for the development and monetization of Cyprus' offshore gas resources, offering flexibility and reliability in the options for the marketing of the gas. No doubt, this large energy infrastructure will upgrade the geostrategic role of Cyprus in the Eastern Mediterranean Region. In addition, this huge development will yield a great benefit to the Cypriot economy and industry, and generate a significant amount of new job positions, business opportunities and revenue, stimulating at the same time the rapid technological development within the manufacturing sector, as well as the development of new industries

such as the production of petrochemicals. The LNG facility, which can be in operation as early as 2020 (provided that the relevant activities for the project resume on a faster pace), can open up the possibility for Cyprus to become a major energy hub – able of handling natural gas from its own fields, as well as from adjacent offshore gas discoveries of the neighbouring countries.

As with every project, however, there is always a level of risk involved, which will have to be managed effectively according to each particular case (as presented in the table that follows).

Table 1: Risks associated generally with oil and gas projects.

Type of Risk	Main Comments
Political Risk	• Commonly exists for all projects across the world. • Difficult to predict or manage.
Permitting Risk (i.e. obtaining all licenses on time)	• Very important as it affects the on-time and on-cost delivery of a project.
Scheduling Risk (i.e. completing all related projects on time)	• Project schedule has an impact on the competitiveness of the export infrastructure against similar projects in other countries all over the world. • This is considered as the most critical risk since it can affect project commerciality.
Safety (refers to Health and Safety issues rather than security issues, which formulate a different kind of risk)	• Safety can compromise the productivity and the schedule of any project at any time. • Particularly important during the construction and operation phases.
Investment Risk	• Common for every project. • The greater the risk, the greater the return (or loss). • Without investing, no returns should be expected.
Construction Risk (i.e. inadequacy of materials/workforce)	• Human resources are crucial for the successful and on-time completion of a project. • Local experienced human resources in specialized sectors (such as the oil & gas sector and the petrochemicals industry) are very limited at the moment in Cyprus.
Public acceptance (i.e. acceptance of a project by the public or a community)	• No project can be implemented and no development can take place unless it has the 'green light' from the affected communities.
Third Party Stakeholders (i.e. involvement of third parties in a project)	• Third parties can prove useful and important for a successful project, but at the same time they can introduce complexity and delays.
Security Risk (refers to mainly actions of sabotage, criminal acts, vandalism, external threats and terrorist attacks, including cyber-attacks)	• A very real and unpredictable risk/thread. • Can cause severe physical damage to a project (whether under development or in operation)

The needs in human resources for certain specializations/disciplines for large projects in oil and gas in Cyprus were first recognized in 2006. Since then, various activities unfolded towards empowering and educating people, through training programmes in the technical and managerial professions of the oil and gas industry (a timeline of related events is presented in the table below[59]).

Table 2: Timeline of related events in the education and training of human resources in Oil & Gas matters.

Year	Main Event(s)
Mid 2011	• Commencing of training programmes and educational material offered by the Energy Service (Ministry of Energy, Commerce, Industry and Tourism) regarding the oil and gas sector and energy in general.
Late 2012	• Completion of the Study of the Cyprus Human Resources Development Authority (HRDA) on the early identification of needs for employment and training for effective management of natural gas in Cyprus.
2012/2013	• Various academic institutions in Cyprus began to offer a series of degrees in the oil and gas sector.
Early 2013	• Noble Energy completed a study on the local content (labour) requirements for the Cyprus LNG Project (construction phase and operational phase).
Late 2013	• A new, two-year long, Professional Diploma in Oil & Gas was established. • This programme was specifically designed to educate and train students in professions related to the technology, practices, processes and operations employed in the oil and gas sector, thus preparing them for becoming skilled blue-collar workers, such as mechanical engineering technicians, electrical engineering technicians, welders and drilling engineers. • The objective is to produce well trained and qualified personnel able to be employed in the technical roles within the petrochemical and oil & gas industries.

N. EU Demand and Supply Facts & Projections

Concerning gas production, consumption and supply within the European Union, the following facts can be noted:[60]

- The share of fossil fuels in the energy mix fell to 77% in 2013, a record low, while renewables reached a record high of 6.6%.
- The consumption of natural gas declined in 2013 by 5.4 Mtoe (1.1%).
- Production of natural gas also declined in 2013 by 1.0 Mtoe (0.5%).
- With fossil fuel consumption declining faster than production, the EU's

fossil fuel imports fell by 0.6% to 921.6 Mtoe in 2013, the lowest level in a decade.

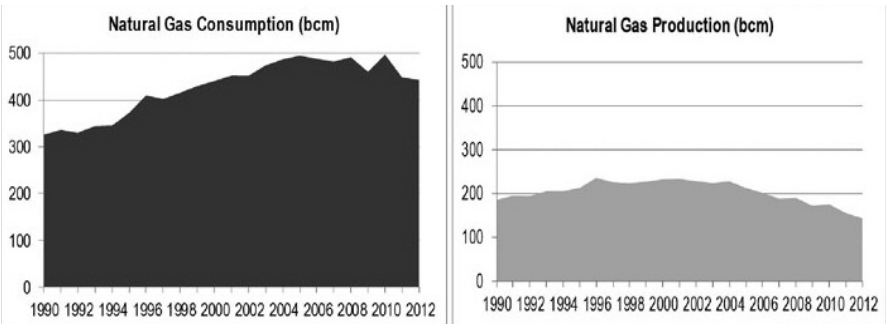
- The EU's natural gas imports continued to shift from LNG towards pipeline with net LNG imports in 2013 down by 29.7% and net pipeline imports in 2013 up by 3.7%.

The Proven Gas Reserves of the main gas producing countries of the European Union (i.e. Denmark, Germany, Italy, Netherlands, Poland, Romania, and United Kingdom) at the end of 2013 were around almost 52 tcf, while those of Norway alone were 72.4 tcf.[61]

The following time-trends also hold regarding gas production and consumption within the European Union[62] (see also charts that follow[63]):

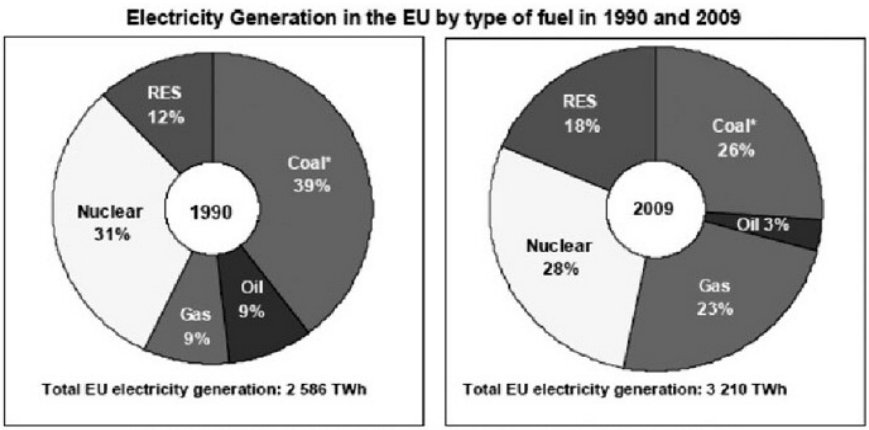
- 1.3% mean annual increase in natural gas demand for 2000-2010 (the European Union is a mature market, focused mainly on energy efficiency & RES).
- Declining trend in natural gas production: 3.3% mean annual decrease during the last decade (mainly due to the gradual depletion of North Sea gas fields).

Figure 28: EU Natural Gas Consumption and Production figures.



Natural Gas however, still remains as an important fuel with a relatively high share in power generation. Around 25% of the electricity generated comes from the combustion of natural gas. There is also a significant increase of natural gas share in the electricity generation noted in the last years (see figure below[64]).

Figure 29: EU Electricity Generation by type of fuel.

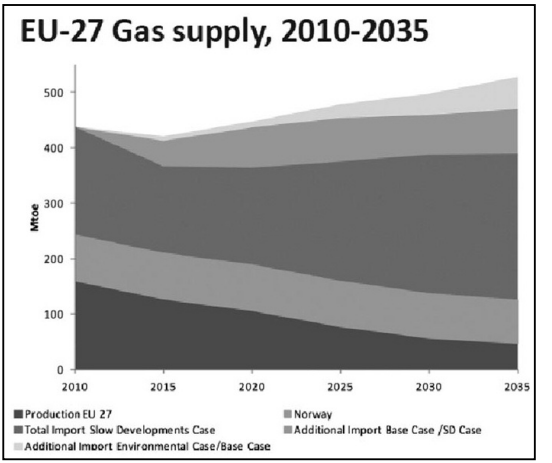


On the gas demand and supply within the European Union, the following projections have been made.[65]

- Energy demand in the EU has peaked and is expected to fall by 6% by 2035.
- Demand for fossil fuels will decline in 2035 by 19% with losses in oil (-27%) and coal (-53%), and overwhelming gains in natural gas (+17%).
- Fossil fuels will account for only 67% of EU's energy consumption in 2035, down from 77% in 2013.
- Power demand will rise by 9% with renewables increasing their share from 13% to 34% in 2035, matching that of fossil fuels. Gas will however overtake coal in 2028.
- Given similar declines in both production and consumption, import dependency will remain relatively constant at around 55% up to 2035.
- The EU will be overtaken by China as the world's largest energy importing region in 2030, but it will remain the largest net importer of natural gas.
- Production of natural gas will decline in the EU by 2035 by 46%.
- Imports of gas will rise by 49% by 2035, while imports of oil (-23%) and coal (-49%) will decline. The EU's gas import dependency will rise from 66% to 84% by 2035.

The following main trends, as recorded today, are expected to project to 2035 (see also chart on the right[66]):

Figure 30: EU Gas Supply projections to 2035.



- Gas production in the EU is declining (and so do the imports from Norway).
- At the same time, the demand for additional (external) gas imports is rising (this trend will become even stronger as an outcome of the restriction on the use of coal).
- The share of natural gas in EU's primary energy consumption will remain high (i.e. mainly for power generation purposes).
- The exploitation of shale gas within the EU raises a number of concerns as regards possible environmental impacts (in addition to being more challenging than conventional gas sources), and thus is not expected to affect the gas production or import figures.

Conclusions

The discovery of substantial quantities of natural gas offshore Cyprus by Noble Energy at the end of 2011 constituted a historic development for the island and filled its people with feelings of optimism for the future. For the Republic of Cyprus, whose economy was being dominated for many years by the financial services and tourism sector, and whose prospects have been overshadowed by the enforcement of various austerity measures as a consequence of the global economic crisis, the existence of natural gas reserves (without excluding the possibility of oil discoveries) offers a path out of the vicious circle and back to prosperity.

However, decisions on how to develop the hydrocarbon resources located within the exclusive economic zone of Cyprus and the ways to harvest the

benefits from their exploitation to the maximum extent are not straightforward. What is more, such decisions are complicated by the historically tensioned geopolitical setting of the Eastern Mediterranean Region.

Cyprus remains to this day an isolated 'energy island' since it has no interconnections with the trans-European electricity or gas networks, neither the necessary infrastructure to be able to take part in the single European energy market. This sets an additional burden on the competiveness of the local enterprises, the economic balance and the cost of life in general.

The visit in Cyprus and subsequent statements of the Vice-President of the United States of America, the inauguration of the new Egyptian Government, the continuous and strong interest of Israel in natural gas exports through Cyprus, the aggressive exploration activities by Eni, the presence of a global oil & gas firm like Total in Cyprus, the strengthening of the relations with Lebanon, the common efforts between Cyprus and Greece, and the prospects for large oil findings in the region, are just some of the signs highlighting that everything is moving towards the beginning of the 'hydrocarbons era' in Cyprus, and the booming of the hydrocarbons industry in the Eastern Mediterranean Region.

The world economy has been in turmoil for the past five years and this had a very negative impact on the economies of certain European countries in particular, especially those of Cyprus and Greece, which are now both on an economic recovery path. However, the inevitable austerity measures still remain in effect and suppress the full and true recovery of the economy. It is only through effective and long term growth and development that the economy can re-stabilize again and begin to prosper. To this end, oil and gas have their own particular role to play. The large investments for the infrastructure and installations necessary for the production and export of oil and gas can provide a firm foundation for the restructuring of the macroeconomic and microeconomic indicators, bringing long term monetary benefits both to the country and its citizens, through direct or indirect involvement in the hydrocarbons industry.

Equally important factors are the geopolitical and exploration and production challenges; bilateral or trilateral cooperation, pipelines versus shipping, risks and returns, technical issues, are some of these challenges. In addition, the market outlook, that is, demand and supply trends, the maritime

transportation of oil, LPG-LNG-CNG, shale gas, sustainability, energy alternatives, energy prices, finance and investments, and new innovations/ technologies, all complete the global energy network.

Based on the abovementioned facts, the new situation, as it shapes today, renders the Cyprus energy sector as the key for the achievement of the goals for economic resurgence and growth. However, on the other hand, it is true that the discovery of hydrocarbon resources entails challenges, opportunities and critical issues which have to be addressed, such as:

- The need to transform the hydrocarbon wealth into a sustainable, equitable and human-centered development;
- The need to build a broad consensus on the efficient management of the wealth resulting from hydrocarbons; and
- The need to develop appropriate proactive measures to safeguard the security and environmental integrity of the island.

The immediate and short-term plans for further exploration activities offshore Cyprus include the following:[67]

– Block 12 (late 2014 / early 2015)

- Drilling of a second Hydrocarbon Exploration Well (in a new prospective structure).
- Drilling of a second Hydrocarbon Appraisal Well within the 'Aphrodite' Discovery (subject to the evaluation of the well data in 'Ishai').

– Blocks 10 and 11 (within 2015/2016)

- Drilling of two Hydrocarbon Exploration Wells (one in each Block).

– Blocks 2, 3 and 9 (2014/2015)

- Commencement of drilling by end of summer 2014 for a series of Hydrocarbon Exploration Wells (4 in total), as follows:
  - Exploration Well in Block 9
  - Exploration Well in Block 2
  - Exploration Well in Block 3
  - Exploration Well in Block 9

Despite the fact that the current exploration plans in Cyprus are progressing well, there is still a number of outstanding issues that need to be resolved. The

LNG Plant should be targeted as the preferred gas monetization option (not only for Cypriot and Israeli gas, but also for the rest of the potential gas deposits in the Eastern Mediterranean Region), since it can offer the necessary export market flexibility and more significantly, could handle additional gas from neighboring regional countries. The steps for the implementation of such a project should be pursued at a fast pace. The main outstanding issues and the next steps that will need to be carried out are the following:

- Conclusion of the negotiations and signature of the *agreement* between Cyprus and the consortium of Noble Energy / Delek / Avner, which will determine the technical and commercial basis for the project of a natural gas liquefaction terminal in Cyprus.
  - ➧ This stage is very important for Noble Energy to be able to evaluate the facts and reach a *final investment decision* for developing the 'Aphrodite' Discovery.
  - ➧ Need to also conclude any other relevant *project agreements* with all counterparts.
  - ➧ These *agreements* should provide the basic negotiating tool for any future parties who may wish to export their gas through the LNG Plant in Cyprus.
- Decision on Cyprus' involvement in the natural gas liquefaction terminal.

Given the current difficult economic situation, the State's involvement could be limited to infrastructure and services that will be supportive for the construction and operation of the liquefaction plant, and which can generate significant revenue and bring other benefits to the State (such as job creation and expertise).

- Creation of a bilateral *framework of cooperation* with Israel, for natural gas exports from neighboring fields (e.g. Leviathan) through the natural gas liquefaction terminal in Cyprus.
  - ➧ This will have a positive impact on the viability of the project and for securing funding for the project with more favorable terms.
- Conclusion and signature of the relevant agreements with Israel and Lebanon, for the joint exploitation of hydrocarbon deposits extending across the median line.

- Establishing a National Hydrocarbons Fund, through the drafting of the relevant legislation.
- Creating a more favorable business environment for implementation of projects in the field of services/supplies for the oil and gas industry, aiming, apart from the domestic market, to serve also the regional market of the Eastern Mediterranean.

Regarding the gas pipeline export options for Cyprus, a brief but relevant analysis is herewith presented. Turkey is a large market, relatively close to Cyprus, buying gas at premium prices. However, the *Pipeline through Turkey* route must be absolutely excluded, since gas exports through Turkey will effectively allow control of Cypriot gas flows by Turkey. On the other hand, the *Pipeline to Turkey* option entails geopolitical issues (such option should only be discussed following resolution of the *Cyprus Problem*). Greece is another promising market and particularly, a promising transit country for the Central Europe through Italy. There are excellent political ties between Cyprus and Greece, but a potential subsea pipeline option (as mentioned earlier, this is an EU project of common interest, jointly proposed by Greece and Cyprus) would limit export capacity flexibility, while it may also prove technically and economically unfeasible. The large depths (exceeding in some locations the 2,000m), combined with an active seismic environment and large anomalies of the sea bottom, are some of the key challenges facing such a project. This gas pipeline project will undergo a technical and economic evaluation, as part of a feasibility study (if feasible, such a pipeline could be used to deliver additional volumes of gas to Europe via Greece, in parallel with the LNG export option).

Cyprus is still at the early stages, but with rational decisions and good management/organization of all relevant aspects and issues regarding its hydrocarbon prospects, in order to overcome the present technical, geographical and economic challenges, it can certainly experience significant geopolitical and financial benefits, as well as growth and prosperity for the years to come.

Abbreviations & Units of Measurement

2-D – two-dimensional
3-D – three-dimensional
bbl – 'blue' barrels of liquid (barrels of oil)
CBM – Coal Bed Methane
CNG – Compressed Natural Gas
CO – Carbon Monoxide
CO2 – Carbon Dioxide
DME – Di-Methyl Ether
EEZ – Exclusive Economic Zone
EPSC – Exploration and Production Sharing Contract
EU – European Union
FLNG – Floating Liquefied Natural Gas
GTL – Gas to Liquids
H2 - Hydrogen
km – kilometer (one thousand meters)
line-km – line kilometer
LNG – Liquefied Natural Gas
LPG – Liquefied Petroleum Gasses
Mtoe - Million Tonnes of Oil Equivalent
MC2D – MultiClient 2-D
NGLs – Natural Gas Liquids
ORVs – Open Rack Vaporizers
PGS – Petroleum Geo-Services
RES – Renewable Energy Sources
sq. km – square kilometer
SPAs – Sales & Purchase Agreements
tcf – trillion cubic feet
UNCLOS – United Nations Convention on the Law of the Sea
USGS – United States Geological Survey

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