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THE ROLE OF LIQUEFIED NATURAL GAS IN EUROPE

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Abstract

Our modern society is unimaginable without energy. We hardly notice how our lives are interspersed with energy and how essential it is. As technology became more sophisticated during the history, so the energy-need of humanity increased. In parallel, clear periods can be separated according to dominant energy sources: wood was changed by coal, then oil, and since the 1970s and the 1980s it is natural gas that has gained a more and more important role.

Expansion of natural gas was launched by high oil prices caused by the oil crisis, but nowadays there are other important reasons too. In order to secure energy supply, countries try to widen their demand portfolio by involving various kinds of energy sources, and they try to purchase these from different producers. Stronger competition will not let prices to rise excessively. Besides, greater care is brought to bear upon environment and to moderate global warming. This latter is favorable to the expansion of natural gas since it burns clearer than other fossil fuels (like coal and oil) thus it produces smaller emission.

Liquefied natural gas (referred to henceforth as LNG) is actually the liquid version of natural gas, so it has similar advantages or maybe more. Its greatest benefit that the volume of natural gas reduces by a factor of more than 600 in the course of liquefaction thus LNG can be transported at great distances much more economically, moreover, it can be sent to places where pipelines are impossible. Due to this, LNG contributes to the diversification of energy sources and to the improvement of supply security, and by virtue of its cleaner composition it increases greenhouse effect less.

Key words: liquefied natural gas (LNG), liquefaction, energy, supply security, import terminal.

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What is LNG?

LNG is actually the liquid version of natural gas, that is gained by cooling the gas to -161 ^{o}C. In the course of refrigeration, the volume of natural gas is reduced by 600 times thus it can be transported at great distances much more economically. The extracted natural gas contains 82 percent of methane, and beside this ethane, propane, butane, heavier hydrocarbons and a smaller amount of nitrogen, oxygen, carbon dioxide, sulphides and water.[1] Before liquefaction, contaminants have to be removed from natural gas, because sulphur and carbon dioxide are corrosive to LNG equipment, and water and hydrocarbons could freeze out and could cause equipment blockage. Thus LNG contains approximately 95 percent of methane,[2] and after regasification it will be a clearer material than the original natural gas. Because of this, it burns clearer and produces less emission.

Liquefied natural gas is colorless, odorless, non-corrosive, non-toxic and non-carcinogenic. However, in unventilated confinement it can cause asphyxiation like other gaseous materials. Natural gas is not odorized before liquefaction, only after regasification because the odorant would freeze out as a solid during cooling.

LNG is stored in specially designed tanks both on ships and on land; these tanks have multiple insulation and they resist extreme cold. In contrast to public belief, LNG is stored at normal atmospheric pressure so in case of leaking there would not be massive release of energy that would result in explosion. Due to the removal of contaminants, LNG does not contain an ignition source thus it does not burn by itself. Three components must be present in the right combination for burning or exploding: the substance, oxygen and heat. So LNG vapors are only flammable when mixed in an exact 5 to 15 percent concentration with air and there is an ignition source nearby.[3]

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[1] CEE, 2007, p. 16.

[2] Methane content of LNG depends on the cleaning process so it can change from country to country. LNG produced in Alaska contains 99,72 percent of methane, while the Algerian one contains only 86,98 percent (CEE, 2007, p. 17.)

[3] If the LNG concentration is lower than 5 percent it cannot burn because of insufficient fuel. If the concentration is higher than 15 percent it cannot burn because there is insufficient oxygen.

History of LNG

Liquefaction of natural gas is not a recent technology; its history dates back to the 19th century when British chemist and physicist Michael Faraday experimented with liquefying different types of gases. The first compressor refrigeration machine was built by a German engineer, Karl Von Linde in 1873, Munich. The first LNG plant was built in 1912, West Virginia, United States, and it started operating five years later. However, the industry began to fulfill itself during the 1940s and the 1950s: the first commercial liquefaction plant was handed over in 1941, Cleveland, Ohio, and in 1959, the first LNG tanker, *The Methane Pioneer* carried a cargo from Lake Charles, Louisiana to Canvey Island, United Kingdom. Getting enthusiastic about the success of transporting safely across the ocean, seven further LNG deliveries were sent off in the next 14 months.[4]

In 1961, Great Britain signed a 15-year contract with Algeria to import almost 1 million tons of LNG per annum. Thus the United Kingdom became the first LNG importing country in the world and Algeria became the first exporting country. The latter built a liquefaction plant in Arzew in order to comply with the contract and delivery started in 1965. Following the Brits, France signed a similar deal with Algeria in 1962.[5]

Asia joined the LNG trade in 1969 when the Alaskan Kenai plant (which is one of the oldest, continuously operated LNG plants in the world) started shipping liquefied gas to Tokyo, Japan. The first Asian producing plant began operating in 1972, Lumut, Brunei.

In the 1970s, four marine terminals were built in the United States that reached their peak receipt volume in 1979. Then the amount of imported LNG began to decline because of the North American gas surplus and price disputes with Algeria, the sole LNG supplier of the USA at that time. Two plants were mothballed and they were restarted only after 2001 when gas demand and prices began to rise again and LNG industry got a new impulse.[6]

In parallel, LNG trade expanded gradually in Europe and in Asia. Libya started delivering to Spain and Italy, and from the 1980s, Malaysia and Australia also became exporters. In 1997, Qatar joined the LNG trade as the second Middle Eastern producer, and Trinidad and Nigeria followed it in 1999. In 2000, Oman launched its first cargo to Korea.[7] The world's first offshore, ship-based regasification facility was handed over in 2005 in the Gulf of Mexico. Due to the growing interest, LNG industry keeps expanding and many proposed, planned and accepted projects are waiting for realization.

The LNG value chain

The LNG value chain or supply chain is the process by which the extracted natural gas is delivered to consumers in a liquefied form. It requests relatively expensive investments: the whole process costs 7-14 billion dollars from the beginning till the end. The value chain has four components:

– exploration and production;
– liquefaction;
– shipping;
– storage and regasification.

The fifth element can be the consumers who get the regasified LNG through the normal pipeline system.

The *first phase* starts with geologists and other experts who try to find natural gas under the ground. Explorations extend to land and oceans as well. In 2009, the total proven natural gas reserve of the world was 187,49 trillion cubic meters; its 40,6 percent was in the Middle East and 31,2 percent was in the territory of the former Soviet Union. The European Union owns only 1,3 percent of the total reserves.[8] These figures, of course, do not cover all underground natural gas since many reserves are not discovered yet. Besides, higher energy prices result in bigger amount of natural gas that is exploitable economically.

Exploration and exploitation need financial capital that can cover the costs of plant construction and development, drilling, delivering, etc. All of these projects have geologic risks since there is a chance that the quantity of natural gas reserves is not enough for economical exploitation or geological conditions are unfavorable for drilling.

(www.sempralng.com/Pages/About/FAQ.htm)

4 CEE, 2007, pp. 13-14.

5 http://www.sempralng.com/Pages/About/History.htm

6 CEE, 2007, p. 15.

7 http://www.sempralng.com/Pages/About/History.htm

8 Statistical Review of World Energy 2010, p. 22.

After exploitation, natural gas is sent to the *liquefaction plant* by pipelines. These plants work as export terminals as well; in 2007, 23 such terminals were in operation worldwide and their total capacity was 170 million tons per annum. Besides, 91 terminals were under construction and further 285 were under planning. In 2009, Qatar was the first (28 percent) among the biggest exporting countries; it was followed by Australia (14 percent), Algeria (12 percent), Trinidad & Tobago (11 percent) and Nigeria (9 percent).[9] The first step in the liquefaction process is the removal of contaminants from natural gas; it results in a gas mixture that contains about 95 percent of methane. After this, the gas is cooled down to -161 ^{o}C in three steps in several parallel units while it becomes liquid and its volume reduces by 600 times. The cryogenic liquid is clear and its density is about 45 percent the density of water.

Until it is loaded into a ship, LNG is stored in tanks that have good insulation and bear extreme cold. These storage tanks are double-walled and they are really “tanks within other tanks”. The inner one is made of a 9 percent nickel steel alloy that resist cold, the outer one is one meter thick and is made of concrete or carbon steel so in case of leaking the outer tank will collect LNG. Between the two layers, there is a perlite insulation to protect the liquid from getting warm.[10]

LNG is *delivered by huge vessels* to the destination point; on shipboard, liquefied gas is stored in similar tanks as described above. LNG carrier ships are approximately of the size of an aircraft carrier: they are about 280 meters long, 44 meters wide and a 10-meter part is under water. Their capacity is about 125.000-138.000 cubic meters and their construction costs are around 160 million dollars.[11] Nowadays, there is a stronger demand for bigger ships as well that have a capacity of 160.000-170.000 cubic meters. Q-Flex[12] vessels that have a capacity of 200.000-250.000 cubic meters began operating in 2007, and the larger Q-max vessels were launched in 2008; their advantage is economies of scale, their drawback is inflexibility since navigation possibilities and port access is limited because of their big size. In the future, smaller vessels with 70.000 cubic meters capacity can be popular as well; these Med-max types would serve the terminals now under construction in the Mediterranean.[13]

The current LNG fleet has 250 vessels and has a capacity of 31 million cubic meters. By 2030, these numbers can triple; however, in case of the production of bigger vessels less ship will be in service. Due to the quick boom of the recent years, 40 percent of the vessels are less than five years old and only one quarter of the fleet is older than 20 years. Besides, life expectancy is quite high (35-40 years) and ships are constructed continuously – these facts substantiate the optimistic forecast concerning the growth. LNG carriers are specifically designed to prevent tank rupture or leakage in an accident. Thus ships are double-hulled and well-insulated tanks are placed in the inner hull. According to cargo containment systems, three types of vessels can be distinguished: the spherical (or Moss) design, the membrane design and the structural prismatic design. Historically, most ships used spherical tanks that are easy to identify since the top half of the tanks are visible above the deck. However, current trends proceed towards the membrane design: in 2006, 44 percent of the vessels were spherical and 51 percent were membrane design, and 85 percent of the orders between 2005 and 2010 referred to membrane designed ships and only 13 percent to Moss types.[14]

After a 4-30 day long voyage, the carrier arrives to the destination point, to the *import terminal*. In 2007, there were 58 such terminals in the world that received 142 million tons of LNG per annum in total. Docks, storage tanks, vaporizers and other equipment for regasification are placed in the import terminal. LNG is pumped from the ship to such cooling tanks as mentioned above and it is stored there until it is needed in gaseous state.[15] Then it is pumped at higher pressure through heaters and vaporizers so the liquid gets warm and becomes gas. Equipments can be warmed by direct-fired heaters, heated water or seawater. After this, natural gas enters the pipeline system at regulated pressure from where local gas utilities transmit it to consumers or it is placed in underground storage facilities.

Consumers get the fuel in gaseous state, they not even meet LNG. They do not perceive any difference compared to natural gas that arrived from extraction place to destination point through pipelines. Thus LNG is used for the same activities as pipeline natural gas: for heating homes, producing electricity, as raw material or fuel. Besides, LNG is planned to use in liquid form too, namely as fuel for ships. The basic idea

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[9] Statistical Review of World Energy 2010, pp. 30-32.

[10] http://www.lngfacts.org/About-LNG/terminal-Safety.asp

[11] CEE, 2007, p. 23.

[12] The “Q” in the vessel’s name refers to Qatar since these ships depart from the Middle East, basically from Qatar. Because of their big size, they can only ply on certain water routes thus their future is doubtful. Duhail is a vessel of this type: recently it is the biggest LNG carrier in the world and it delivers liquefied gas from Qatar to Spain.

[13] JRC, 2009, pp. 23-24.

[14] CEE, 2007, pp. 21-22.

[15] Beside terminal storage, approximately 240 storage facilities were also in operation in 2007 worldwide. They store LNG in low demand periods and send it back to regasification plants in peak times.

is that LNG is a clearer fuel than natural gas so it could reduce emissions caused by shipping.[16] The European Union has launched a program in this topic that is headed by the Norwegian energy company, GASNOR AS. In the first place, they focus on the Baltics and they would like to construct terminals with LNG refuelling stations in Lübeck, Bergen, Göteborg, Stockholm and Swinemünde. The first one is planned to be finished in 2012 in Lübeck; but unfortunately, the existing ferries cannot be converted to run on gas so they have to order new ships from Norway too.[17]

Safety questions

Of course, production and treatment of LNG have some hazards just like of other fuels, but they are manageable. In the past 50 years, this industry had an enviable safety record, in particularly if we compare it to other refineries or petrochemical plants. Albeit there were smaller incidents, during the 45.000 voyages and 200 million kilometers there was not any serious accidents neither on ocean, nor in ports. Altogether, eight marine accidents have resulted in spillage of LNG with some hulls damaged because of cold fracture, but no cargo fires have occurred. Seven incidents without spillage were recorded; two from groundings, but due to quick repair leakage was avoided. There have been no LNG shipboard fatalities.[18]

In the early years of the industry, several fatal accidents happened but they were in isolated inland facilities. Learning by these cases, more stringent regulations have been implemented, and due to more improved safety technologies, risks related to LNG have decreased significantly. For instance, in 1944, a Cleveland storage plant was planned to be expanded but there was a shortage of stainless steel because of the world war. Shortly after the tank was placed in service, it failed allowing LNG to escape and a vapor cloud filled the surrounding streets and storm sewer system. The gas ignited and 128 people lost their lives in the adjoining residential area. Since then, it is a compulsory rule that the inner storage tank has to contain 9 percent of nickel steel.[19]

In the recent past, an explosion in Algeria brought the concerns related to LNG to the surface. In 2004, gas escape occurred at a liquefaction plant and a boiler ignited the vapor cloud in a confined space causing an explosion and fire. But we have to notice that this accident happened at an export terminal; structure, equipment and technology are different at an import terminal, for example, they do not use steam boilers.[20]

Concerns become stronger in parallel with LNG's growing expansion. Lots of people are afraid of terrorist attacks since the LNG stored on ships and at terminals are suitable for exploding.[21] Cargos of 10-20 million dollars value are exposed to pirate attacks: for instance, LNG carriers were occupied near the coast of Somalia in 2005 and close to Kenya in 2010. People also fear accidents caused by fire or explosion.

In the interest of safe LNG production and transportation, authorities worked out severe regulations. It is important to point out that onshore LNG facilities are industrial plants at the same time thus regulations and environmental standards relating to them are valid to LNG units too. Besides, stringent rules are laid down both on national and international level; the International Maritime Organization stands at the top of the regulating. Due to the severe safety policy and practice, LNG spillage arising from collision or grounding has little chance.

There are several factors and systems in practical operation that serve material and personal safety. These can be separated into four groups. Primary containment means that the construction of LNG facilities and vessels has to be preceded by proper engineering design and appropriate materials have to be used. It mainly relates to storage tanks but the other parts of ships and plants also have to meet the requirements. According to the secondary containment, dikes have to surround storage tanks at terminals in order to LNG could be fully contained and isolated from the public in case of leaking or spillage.

The third element involves the safety systems on shipboard and at terminals. Their primary goal is to minimize the frequency and size of LNG releases and to prevent harm from potential associated hazards, such as fire.[22] LNG carriers are provided with sophisticated navigation systems that involves anti-collision radar, AIS[23] and GPS[24]. Thus it is easy to monitor the ship's position, nearby traffic and other hazards, and

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[16] Although shipping is efficient, it is a quite polluting way of transport. NO_x emission of a tanker is equal to the emission of 20.000 cars.

[17] Driessen, 2009.

[18] CEE, 2007, pp. 27-29.

[19] CEE, 2007, p. 29.

[20] http://www.lngfacts.org/About-LNG/FAQ.asp

[21] It is basically a characteristic of the American people since 11 September 2001.

[22] CEE, 2007, p. 32.

[23] Automated Information System.

[24] Global Positioning System.

due to this, the chance of collision or grounding can be minimized. If it still happened, ships' double-hulled structure would diminish the probability of leaks and ruptures from the beginning. Besides, storage tanks are provided with gas detection equipment that is so sensitive that it can detect leakage through a hole the size of a pinhead. Every vessel is equipped with fire and gas detecting systems that first alerts the crew than it can automatically activate the fire fighting systems. In case of emergency, emergency shutdown system is automatically started and it significantly diminishes the risk of an accidental release of LNG. If an onboard emergency occurs that requires external assistance, a global maritime distress system automatically transmits signals.[25] Similarly to ships, terminals are also provided with sophisticated alarming and safety systems. The ESD[26] is normally linked to automated gas, liquid and fire detection equipment and it can be started automatically or manually. First, it identifies the problem and then in case of need, it shuts down operations, limiting the amount of LNG releases. Besides, there are detectors for monitoring LNG levels and vapor pressures within storage tanks and closed-circuit television equipment for monitoring all critical locations of LNG facilities.[27]

The fourth element of safety guarantee is to maintain separation distances from residential areas, namely defining security zones around facilities and ships. Onshore LNG plants and storage tanks have to be separated appropriately in order to protect inhabitants in case of an unlikely catastrophe. Security zones have to be big enough so that flammable vapors will not reach the facilities' property lines and heat radiation from a potential fire will not impact those beyond the facilities' property lines. Around the vessels, moving zones are defined to avoid collision. The drawback of these security zones is that LNG facilities take up quite big area due to them, and tankers can obstruct maritime traffic mainly near export and import terminals.

Environmental issues

Many people have worries about the environmental effects of LNG. The greatest fear results from the public belief that in case of a maritime accident, LNG spillage has similar consequences to an oil catastrophe. But this is not true. LNG is at its boiling point at -161 ^{o}C so if it contacts with warmer air it will vaporize immediately. If a rupture occurred on a tank of a vessel and LNG started leaking, it would evaporate on air or if the leakage was under the sea, LNG would come up to the surface (since its density is less than the water's) and it would evaporate from there. Thus spilled LNG does not result in a slick neither on water nor on soil and it evaporates leaving no residue. Because of this, no environmental cleanup is needed after a leakage.[28]

Since LNG contains about 95 percent of methane, it burns much clearer than other fossil fuels. Regasified LNG produces much less emission in the course of burning than the original natural gas. Since LNG carriers use the gas released from their storage tanks beside oil, they are less polluting than other ships.

It is needed to be added, however, that LNG value chain has a greater impact on environment than pipeline gas because liquefaction, shipping and regasification all need energy that is accompanied by emission. It raises the question of choosing between energy security and reducing emission.

The role of LNG in the European Union

Beside North America and Asia, Europe is one of the main gas consumer regions in the world. Europe and Eurasia together possess 33,7 percent of proven natural gas reserves, however, the bulk of these is found in the territory of the former Soviet Union; the European Union has only 1,3 percent of the reserves. In 2009, the countries of the Union produced 171,2 billion cubic meters of natural gas altogether: its lion's share was used by the producer country itself and a smaller proportion was sold in the internal or external market. In comparison with this, the EU's total gas consumption was 459,9 billion cubic meters in 2009 so the deficit was almost 290 billion cubic meters; it had to be supplemented with imports. Looking through the data of the past ten years, the growing gap between demand and supply is clearly visible: the difference between domestic production and consumption has grown with 11 billion cubic meters on an average per annum.

[25] http://www.lngfacts.org/About-LNG/Ship-Safety.asp
[26] Emergency Shutdown System.
[27] http://www.lngfacts.org/About-LNG/terminal-Safety.asp
[28] http://www.lngfacts.org/About-LNG/Environment.asp

1. Table: Production and consumption of natural gas in the European Union (billion m^3)[29]

EU's total	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
production	226,6	231,9	232,8	227,6	223,6	227,3	211,9	201,2	187,5	189,4	171,2
consumption	428,8	439,7	451,0	450,3	471,3	485,5	493,6	486,7	481,2	489,9	459,9
Difference	202,2	207,8	218,2	222,7	247,7	258,2	281,7	285,5	293,7	300,5	288,7

Imported natural gas arrives to Europe mainly through pipelines. Among pipeline gas supplier countries, Russia is the first with a share of 28 percent and Norway is the second with 15 percent.[30] Beside gaseous fuels, the EU imports LNG too. As I mentioned before, the first LNG tanker carried a cargo to Great Britain in 1959 and two years after, the UK signed a 15-year contract with Algeria to import LNG. Thus Great Britain became the first official LNG importer in the world but France, Spain and Italy also joined the trade soon.

In 2009, 16 percent of the EU's total gas import derived from LNG which is a quite high proportion. At present, seven member states operate LNG import terminals: the United Kingdom, Belgium, France, Spain, Portugal, Italy and Greece. These countries cover their LNG imports in different degrees; sometimes they not even use the total quantity themselves but export a little to other member states.

In relation to the recent gas disputes between Russia and Ukraine, minds have been focused on supply security.[31] Russia closed the gas-taps of pipelines passing through Ukraine several times and dragged into danger the EU's energy supply. To solve the problem, the Union has started building new pipelines on one hand (like Nabucco), and has urged to increase LNG investments on the other hand.[32] It is because LNG can be transported much more economically from distant countries thus gas dependence can be diminished and consumption portfolio can be diversified. Beyond increasing supply security, new suppliers stimulate competition on the energy market thus they can cut consumer prices down. In 2009, the number one supplier of the EU's LNG imports was Qatar that gave more than 29 percent of the total quantity. It was followed by Algeria with 26 percent, Nigeria with 15 percent, Trinidad & Tobago with 12 percent and Egypt with 11 percent.[33]

Regulation and institutions

Energy policy is not one of the EU's common policies; the Union and the member states have shared competence in energetic questions. However, leaders at union level make an effort to bring member states' energy policies closer. The main energetic objectives are security of energy supply, increase of competitiveness, energy efficiency and energy saving, nuclear safety and enhancement of using renewable energy sources.

Concerning natural gas market, one of the most important documents is the 2003/55/EC Commission directive that ordains the liberalization of the gas market in accordance with the principle of progressivity. By virtue of this, big non-domestic consumers have been able to choose their gas and power suppliers since 2004, and every consumer has been able to decide freely since 2007. The other important element was the separation of gas supplier and infrastructure maintainer companies. The directive contains rules specifically about LNG too, namely every member state has to have access to regasification systems in a non-discriminative way which, however, can be refused by the terminal operator if he has good reasons.[34]

In November 2008, the EU presented its "energy security and solidarity" action plan. It is declared in this document that today LNG contributes to diversify the Union's gas demand and to secure energy supply continuity. It ordains that every member state has to have access to LNG capacities, namely onshore terminals and offshore regasification facilities. It is needed to ensure that every member state has direct or indirect access to these facilities based on solidary contracts, and those countries have higher priority that depend on one gas supplier. To develop detailed regulation, the Commission plans to produce an LNG action plan[35] but it has not been done yet.

[29] Statistical Review of World Energy 2010, pp. 24-29.
[30] Statistical Review of World Energy 2010, pp. 31-32.
[31] Since the 1995 White Book on energy policy, the European Union has three main objects: to maintain competitiveness, to preserve security of energy supply and to protect environment.
[32] Among the member states, Bulgaria was touched for the most part in the gas disputes between Russia and Ukraine. There, the shortage was appeased by LNG cargos arrived through Greece.
[33] Statistical Review of World Energy 2010, pp. 31-32.
[34] These kinds of reasons can be lack of capacity, prevention from public service obligations or serious economic and financial difficulties with take-or-pay contracts (Hirschhaussen, 2003, p. 9.)
[35] Brunsden, 2009.

Currently, LNG industry does not have a Union level political or regulating organization. However, there is a European organization to safeguard interests: Gas Infrastructure Europe is an umbrella organization that gathers the actors of gas industry and represents them towards the European institutions and decision-making bodies. The organization has three subdivisions; one of them is Gas LNG Europe (GLE) that gathers the LNG terminal operators.[36] Today, GLE represents 17 LNG terminal operators from seven countries. It aims to promote the development of a fully operational, competitive and LNG-based European internal market that has transparent regulation system and sound investment climate.[37]

LNG import terminals in the EU[38]

Today, there are seven member states in the European Union that have LNG import terminals and regasification plants. Beside the current 17 terminals, there are six more under construction and 29 more are planned to establish in the near future in the territory of the Union. It is clear from these numbers that member states and investors see more and more possibilities in LNG both from a security and a profitability point of view.

The first time when an LNG cargo arrived to the *United Kingdom* was in 1959, on Canvey Island, and in the next 35 years Algeria exported liquefied gas to Britain. However, as gas production from the North Sea increased, LNG imports decreased and gradually phased out. Then the northern gas reserves started declining and the country became a net importer of gas again. Since then, British governments has been encouraging the construction and the development of LNG import infrastructure. One quarter of the UK's gas imports derives from LNG. Currently, four import terminals operate in the country: one on Isle of Grain, the Dragon LNG and the South Hook in Milford Haven and one near Teesside. The total annual capacity of these facilities is 40,4 billion cubic meters, and the main suppliers are Qatar (56 percent), Trinidad & Tobago, Algeria and Egypt. Four other terminals are planned: on Canvey Island, in Port Meridian and two offshore terminals in Anglesey and in Teesside.

2. Table: Existing and planned import terminals in the United Kingdom

	Start-up	Annual capacity (billion m^3/year)	LNG storage capacity (m^3)	Number of tanks	Under expansion
Isle of Grain	2005	13,4	770.000	7	yes
Milford Haven, South Hook	2009	21	775.000	5	no
Milford Haven, Dragon LNG	2009	6	320.000	2	no
Teesside	2007				no
Canvey Island		5,4	240.000		
Anglesey (offshore)		31			
Port Meridian	after 2013				
Teesside (offshore)					

Belgium relies entirely on imports to supply its gas needs and LNG adds up to 30 percent of it. Its only import terminal is situated in Zeebrugge and it has been operating for quite long, since 1987. Belgium's primary supplier was Algeria until 2007, but since then it gets 92 percent of its imported LNG from Qatar. The capacity of the Zeebrugge terminal is typical: it treats 9 billion cubic meters per annum and it has four storage tanks. Currently, Belgium is planning neither capacity expansion, nor construction of new facilities.

3. Table: Existing import terminals in Belgium

	Start-up	Annual capacity (billion m^3/year)	LNG storage capacity (m^3)	Number of tanks	Under expansion
Zeebrugge	1987	9	380.000	4	no

[36] The other two subdivisions are Gas Transmission Europe (GTE) that represents the transmission system operators, and Gas Storage System (GSS) that gathers storage system operators.
[37] http://www.gie.eu/maps_data/lng.html
[38] The chapter was written on the basis of the study of King & Spalding (2006) and the data of Gas LNG Europe. (http://www.gie.eu/maps_data/lng.html)

France is the second oldest and the second largest LNG importer in the EU. In 1962, it signed a contract with Algeria to import LNG, and today it buys 13,07 billion cubic meters per annum; this means 26,6 percent of France's total gas import. At present, three import terminals operate in the country and they have Gas de France as a majority owner: they are in Montoir de Bretagne, Fos Tonkin and Fos Cavaou. Their total capacity is 23,75 billion cubic meters per annum and their total storage capacity is 840.000 cubic meters. Due to their strong economic relations, France gets the biggest share of its LNG from Algeria (58,8 percent) but Nigeria and Egypt are also important suppliers. To expand capacities, the Montoir plant is currently under development and four more terminals are planned. They would be near Dunkerque, Fos-sur-Mer, Le Havre and Le Verdon, and they can be in operation within five-seven years.

4. Table: Existing and planned import terminals in France

	Start-up	Annual capacity (billion m^3/year)	LNG storage capacity (m^3)	Number of tanks	Under expansion
Montoir de Bretagne	1980	10	360.000	3	yes
Fos Tonkin	1972	5,5	150.000	3	no
Fos Cavaou	2010	8,25	330.000	3	no
Dunkerque	2014	10-13	380.000-570.000	2-3	
Fos-sur-Mer	end 2016	8	360.000	2	
Le Havre	2015	9	340.000-510.000	2-3	
Le Verdon		6-9			

Spain has limited reserves of natural gas and since its gas consumption is one of the highest in Europe, it imports most of its demand. In 2009, it imported 36 billion cubic meters of natural gas in total and its three-quarters were LNG. With its six terminals currently in operation and its vast import, Spain has the biggest LNG market in Europe. It joined the trade in 1970 when Libya started transporting there liquefied gas. Since then, import terminals have been constructed in Huelva, Cartagena, Bilbao, Sagunto and El Ferrol beside Barcelona; their total capacity is 58,8 billion cubic meters and they have 21 storage tanks altogether. Supplier countries have a balanced shared in Spain's portfolio; most of them represent 15-20 percent in it. The most important ones are Algeria, Nigeria, Qatar, Trinidad & Tobago and Egypt. Due to the increasing demand for electricity and the construction of gas-fuelled power plants, Spain's gas demand is rising. Because of this, five of the six current terminals are being expanded, and three more facilities are under construction in Gijón, Gran Canaria and Tenerife. These are planned to be finished within a few years but there is no information about further investments.

5. Table: Existing import terminals and terminals under construction in Spain

	Start-up	Annual capacity (billion m^3/year)	LNG storage capacity (m^3)	Number of tanks	Under expansion
Barcelona	1968	17,1	540.000	6	no
Huelva	1988	11,8	460.000	4	yes
Cartagena	1989	10,5	437.000	4	yes
Bilbao	2003	7	300.000	3	yes
Sagunto	2006	8,8	450.000	3	yes
El Ferrol	2007	3,6	300.000	2	yes
Gijón (Musel)	after 2011	7	300.000	2	
Gran Canaria	2013	1,3	150.000	1	
Tenerife	2012	1,3	150.000	1	

Portugal does not produce natural gas at all; it covers all of its demand from import. Natural gas arrives through pipelines from Algeria and Spain but LNG is also imported. In 2009, Portugal imported 4,41 billion cubic meters of gas that added up to 1,1 percent of the EU's total import. 64 percent of the incoming natural gas came in a liquid form thus Portugal is relatively the second largest LNG importer after Spain.[39] Since the imported volume is not that big in an absolute sense, one regasification plant is enough which is placed next

[39] As regards absolute numbers, Portugal is the last but one importer before Greece, but in its own gas import LNG has a vast share.

to Sines. Its annual capacity is 5,5 billion cubic meters and three-quarter of this volume come from Nigeria and 14 percent come from Trinidad & Tobago. Portugal is planning a small expansion in Sines but there is no information about new plants.

6. Table: Existing import terminals in Portugal

	Start-up	Annual capacity (billion m^3/year)	LNG storage capacity (m^3)	Number of tanks	Under expansion
Sines	2004	5,5	240.000	2	yes

In the territory of *Italy*, there are more than 170 billion cubic meters of proven natural gas reserves thus the country extracts and produces gas. Being a big consumer, however, it is forced to import too mainly via pipelines from Russia and Algeria, but the Netherlands, Norway and Libya also transport gas to Italy. LNG's share in the country's total gas import is quite small, 4,2 percent that is covered in fifty-fifty from Qatar and Algeria. Currently, two import terminals are in operation in Italy that have a total annual capacity of 10,4 billion cubic meters. The Panigaglia plant was built back in 1971 to be able to receive cargos from Libya; the Porto Levante terminal was handed over in 2009. Because of the increasing demand for gas, Italian governments support LNG investments: the Panigaglia plant is now under expansion and a new offshore terminal is being constructed near the coast of Tuscany that is planned to be finished this year. Besides, ten new projects are on the agenda, but most of them are only proposed and there is not much information about them.

7. Table: Existing import terminals, terminals under construction and under study in Italy

	Start-up	Annual capacity (billion m^3/year)	LNG storage capacity (m^3)	Number of tanks	Under expansion
Panigaglia	1971	2,4	100.000	2	yes
Porto Levante	2009	8	250.000	2	no
Tuscany (offshore)	2011	3,75	137.000		
Brindisi		8	320.000	2	
Taranto		8	300.000	2	
Porto Empedocle	after 2014	8			
Rada di Augusta		8			
Senigaglia (offshore)		5			
Gioia Tauro	2014	12			
Ravenna (offshore)		8			
Rosignano (offshore)		8			
Zaule	after 2014	8	300	2	
Trieste (offshore)		8			

Greece mainly relies on imported oil to satisfy its energy needs but gas market also develops gradually. Greeks produce a small amount of natural gas but most of their demand is imported from abroad. Less than one quarter of total gas imports is LNG. At present, one regasification terminal is in operation in Greece: it is in Revithoussa, and 71 percent of the received LNG come from Algeria and 23 percent are from Egypt. The terminal has been working since 2000 and it treats 5,3 billion cubic meters of LNG per annum. To diversify its energy sources, Greece wants to expand its LNG capacities: thus the Revithoussa terminal is currently under expansion and two plans are accepted to build new terminals in Astakos and on Crete. Greek LNG cargos can improve not only the local supply security but that one in Central Eastern Europe too which region is touched for the most part in Russian gas disputes. Thus it would be desirable to support the development of Greek LNG infrastructure at an EU level.

8. Table: Existing and planned import terminals in Greece

	Start-up	Annual capacity (billion m^3/year)	LNG storage capacity (m^3)	Number of tanks	Under expansion
Revithoussa	2000	5,3	130.000	2	yes
Crete	2016	2,2	175.000	1	
Astakos		3-8			

Seeing how secure is production and transportation of LNG, *other countries in the European Union* intend to join the international trade to improve energy supply security and to use clearer energy to contribute to environmental goals. In the Netherlands, a new import terminal is under construction near Rotterdam that is expected to be finished this year. Besides, a new facility is planned to be built near Eemshaven and the total capacity of these two plants would be 24 billion cubic meters. There is a terminal under construction in Sweden too, next to Brunnsviksholmen and it is planned to be handed over this year; but its storage capacity will be only 20.000 cubic meters. The Göteborg terminal is currently under study but it is planned to be ready until 2013; its storage capacity will also be small, 10.000 cubic meters. New terminals are proposed in Shannon, Ireland, in Wilhelmshafen and Rostock, Germany, in Klaipedia, Lithuania and somewhere in Poland. In the *neighboring countries of the EU*, there are two regasification plants in Turkey near Aliaga and Marmara Ereglisi, and a new terminal is planned to be built in Ceyhan. Croatia, Albania and Ukraine are also planning LNG investments that can improve energy security in Central Eastern Europe too, similarly to the Greek case.

9. Table: Other import terminals under construction and under study in Europe

	Start-up	Annual capacity (billion m^3/year)	LNG storage capacity (m^3)	Number of tanks	Under construction / Planned
The Netherlands, Rotterdam	2011	12	540.000	3	UC
The Netherlands, Eemshaven	2015	12	360.000	2	P
Sweden, Brunnsviksholmen	2011		20.000		UC
Sweden, Göteborg	2013		10.000	1	P
Ireland, Shannon	after 2013	6,5-10,8	max. 800.000	max. 4	P
Germany, Wilhelmshafen	after 2013	5,2			P
Germany,Rostock	after 2014	2-5	150.000-360.000		P
Lithuania, Klaipeda	after 2013	max. 5			P
Poland	2014	5-7,5	320.000	2	P
Turkey, Aliaga	2006	6	280.000	2	existing
Turkey,Marmara Ereglisi	1994	5	255.000	3	existing
Turkey, Ceyhan					P
Croatia, Krk	2017	10-15			P
Albania, Fiere	2016	8			P
Ukraine, Black Sea coast		10			P

Some issues for consideration

As I mentioned before, importing and using LNG contributes to the diversification of energy sources and thus to supply security. However, diversification is disputable from the supply aspect since natural gas reserves are concentrated more in certain areas of the Earth determining exporter countries. There are three groupings that are relevant to the EU since they can have influence on natural gas and LNG trade: the Middle East, OPEC and GECF.[40] There is overlap between these groupings and those countries have greater influence that are members of more than one group.

The Middle East is seeing the fastest growth in LNG production and export: in the past ten years, the amount of total exports has been tripled and now it is around 30 percent. Qatar's capacity is growing the most quickly: 29 percent of the EU's LNG imports come from here. Although OPEC's share of world LNG exports has declining over the past 20 years, it still provides about half of LNG supply. Beside quantity, the cartel can influence natural gas and LNG markets in two other ways. First, in some regions, particularly in Europe, the price of gas is indexed to oil, thus OPEC has some control over supply prices. Secondly, while exploiting oil associated gas is also recovered so OPEC may make a direct contribution to gas supply too. GECF gathers the world's leading gas producers and represents their interests to ensure that member countries derive maximum value from their gas reserves. 85 percent of the world's total LNG export comes from GECF member states thus a stronger cooperation may result in massive influence on gas markets.[41]

The other important question is that if it is affordable to invest in LNG, namely how cost-effective the production and transportation of liquefied natural gas is. The whole LNG value chain costs 7-14 billion dollars so in total; LNG is one of the most expensive energy sources. Moreover, fall of costs is not expected

[40] Gas Exporting Countries Forum; it was established in 2001.
[41] JRC, 2009, pp. 8-9.

because of constant increase of energy prices, strong demand and the competition for inputs (raw materials of good quality, skilled labor). Thus LNG industry remains in the hands of several energy giants. It is only profitable to start a project if a gas field is large enough to guarantee about 30 years production at a liquefaction plant; otherwise investment costs will not be recovered. Elements of the value chain move between wide cost limits. A greenfield investment i.e. a liquefaction plant built in a new location costs around 500 million dollars per billion cubic meters at the low end. The expansion of an existing plant is cheaper due to economies of scale: a brownfield project costs around 200-400 million dollars per billion cubic meters. Building a regasification plant is relatively cheaper so fast increase is expected in the number of import terminals.[42]

Shipping or transportation has the most volatile cost since it can alter between 30-45 percent of the total cost. Thus this element is likely to define the relative competitiveness of suppliers versus receivers. The greater the distance, the more worthy it is to transport LNG instead of pipeline natural gas: comparing to offshore pipelines, the break-even point is at around 1200 kilometers which means that it is more economical to transport liquefied gas by ships at greater distances. In the case of onshore pipelines, the break-even point is at around 3500-4000 kilometers but the exact number depends on the individual case.[43] In our days, there is a growing demand for bigger vessels in order to reduce shipping costs due to economies of scale. Higher technologies also contribute to cost cutback: modern propulsion systems reduce fuel costs and increase cargo carrying capacity, and beside these, ships have longer operating lives and better security systems that decrease the risk of accidents and thus additional costs.[44]

To sum up, LNG still remains one of the most expensive energy sources so it is expected to be an option for richer countries only. Developing economies, like India or China, are most likely to remain marginal players since they need cheap energy, not just energy.

Conclusion

Examining the production, trade and characteristics of LNG, we can come to the conclusion that its role is growing worldwide, particularly in Europe. In contrast to public belief, LNG is not more dangerous to humans and to the environment than other energy sources: it does not burst into flames by itself, it does not result in a slick neither on soil nor on water, it evaporates immediately when its temperature is higher than -161 ^{o}C. Since its methane content is much higher than the ordinary natural gas', LNG burns clearer thus it produces less emission. The only factor that is against LNG is that a whole value chain is very expensive. Thus, although liquefied natural gas is expected to remain an important component in the European Union's energy mix and it will keep contributing to supply security, it is unlikely to be the EU's energy security panacea. Of course, its importance does not decrease because of this, but it is only one element of the total energy portfolio beside renewable energy sources and other options.

In the next issue, as a second part of this study I will analyze LNG's role in Croatia, particularly the new import terminal on Krk Island planned to be finished by 2017.

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