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Global **LNG Market**

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Contents

Abbreviations

AAV — *Ambient Air Vaporizers*
AGRI — *Azerbaijan-Georgia-Romania-Interconnector*
CCGT — *Combined Cycle Gas Turbine*
CEF — *Connecting Europe Facility*
CEN — *Comité Européen de Normalisation* (European Committee for Standardization)
CNG — *Compressed Natural Gas*
DNV GL — *Det Norske Veritas*, Norwegian classification society headquartered in Oslo
DOE — *Department of Energy*
DSO — *Distribution system operator*
EC — *European Commission*
EC — *European Community*
EEU — *European Energy Union*
ELA — *Energy Law Act*
ENTSOG — *European Network of Transmission System Operators for Gas*
ERO — *Energy Regulatory Office*
ESN — *European Shortsea Network,* an informal agreement of institutions promoting short-sea shipping
EU — *European Union*
FERC — *Federal Energy Regulatory Commission*
FLNG — *Floating Liquefied Natural Gas*
FSRU — *Floating Storage and Regasification Unit*
FTA — *Free Trade Agreement*
HTF — *Heat Transfer Fluid*
IAE — *International Energy Agency*
IMO — *International Maritime Organization*
LNG — *Liquefied Natural Gas*
LPG — *Liquefied Petroleum Gas*
MMBtu — *Million British Thermal Units*
MOSES — *Model of Short-term Energy Security*
NBP — *National Balancing Point*
ORV — *Open Rack Vaporizer*
OTC — *Over-the-counter* (off-exchange market)
PCIs — *Projects of Common Interest*

PGNiG — *Polskie Górnictwo Naftowe i Gazownictwo* (Polish Oil and Gas Company)
PLNG — *Polskie LNG* company
PTS — *Shore-to-ship via pipeline*
SCV — *Submerged Combustion Vaporizer*
SECA — *Sulphur Emission Control Area*
STS — *Ship-to-ship*
STV — *Shell and Tube Vaporizers*
TAP — *Trans Adriatic Pipeline*
TEN-T — *Trans-European Transport Networks*
TEU — *Treaty on European Union*
TFEU — *Treaty on the Functioning of the European Union*
TPA — *Third party access*
TSO — *Transmission system operator*
TTIP — *Transatlantic Trade and Investment Partnership*
TTS — *Truck-to-ship*
UGS — *Underground Gas Storage facilities*
V4 — *Visegrad 4* (Czech Republic, Poland, Slovakia, Hungary)

Introduction

International trade in natural gas dates back to the middle of the 20th century, and the globalization of the gas market began in the 1960s. Large-scale investments were initiated then, involving two parallel distribution channels: export and import gas pipelines, and LNG terminals. The discovery of new sources of natural gas, often in regions far away from the main routes of natural gas supply via pipelines, plus the development of sea transport of LNG, led to dynamic development of the market. In the initial period, the market was largely based on regional connections. But over time, the development of international relations has led to the emergence of a global LNG market based on more and more uniform mechanisms of functioning. The process is undergoing constant evolution towards ensuring greater efficiency of the global market. Liquefied gas is bound to play a significant role in ensuring the energy security of the EU and gradually improving competition on the increasingly integrated energy market. Further expansion of energy infrastructure is essential, as it will improve the chain of supply and distribution of liquefied gas and give EU member states direct or indirect access to the global energy market.

In the LNG supply chain, costs are incurred in four main links: extraction, liquefaction, transportation, and re-gasification. Technological changes and the recent situation in the natural gas sector have had a positive impact on new importers and have fostered exporters' development. The market is becoming more and more competitive, allowing its participants to take advantage of the potential of LNG. Market changes are also promoted by political and legal transformations. The European Union has noted the role of LNG in the implementation of a number of policies, including energy policy, climate policy, environment protection policy, and transport policy. The legal solutions adopted concerning LNG are supposed to support the development of EU objectives such as the security of fuel and energy supplies, environmental protection, or the creation of a competitive market. These objectives are achieved through changes in the regulatory system. The most important ones are connected with supporting competition mechanisms, both on wholesale and retail markets, infrastructure expansion, and greater integration, plus the development of common mechanisms of activity. The EU can see the need to create a common strategy for LNG development in Europe.

Political, legal, and economic determinants will affect the actual availability and use of LNG on the market. The emergence of new suppliers from the USA, Canada, Mozambique, Australia, and even Iran, will definitely

influence the volume of gas available on the market. Gas price, transport capabilities, and freight costs will be of key importance. Other crucial factors will be the mechanisms of LNG contracting and pricing.

The upcoming years are sure to be a key period in the development of the LNG market in Poland. The LNG terminal in Świnoujście will make it possible to market 5 bcm natural gas a year, and even 2.5 bcm more after potential extension. The new system of natural gas reception can be used not only domestically, but also for the development of countries in the Baltic Sea region and in Central and Eastern Europe. Time will show whether the Świnoujście LNG terminal will soon provide gas for Germany, Denmark, and perhaps the Czech Republic, Slovakia and Hungary....

It must be emphasized that the terminal will also be an element of new business models based on LNG, which have never existed in trade before. The relatively high capacities of LNG tanks, the operating costs connected with them, as well as predicted higher gas consumption in the transport sector (sea and road transport), increasingly demanding environmental standards introduced in the EU, and the low competitiveness of the market – all produce the opportunity for many more applications of liquefied gas. The Świnoujście LNG terminal should not only offer the basic service of LNG re-gasification, but also the broadest possible range of extra services for entities that operate or intend to operate as part of domestic and international trade. Success in the new fields of activity connected with the LNG terminal is conditional (apart from the price of gas, because its contracting is beyond the competence of the owner and operator of the terminal) on making courageous, i.e. somewhat risky, decisions concerning the extension of the terminal; setting the scope and parameters of its functionality; and creating an efficient logistic and trade structure. Another condition is patience, which – according to the German saying – "brings roses". From the point of view of Poland and its region, it is essential to consolidate the role of the LNG terminal in Świnoujście on the gas map of Poland and the region. The role may include new applications of natural gas (including LNG) in Poland, or the safeguarding of supply of these fuels to the markets of neighboring countries. The question arises whether Poland will be able to purchase liquefied gas at a lower price than gas delivered via pipeline, and from which producers.

These elements are the subject of this book, made up of 6 chapters. The work was inspired by the discussion initiated at the scientific conference devoted to energy security on the common EU energy market, which took place in 2015 at the Faculty of Management of the Ignacy Lukasiewicz Rzeszow University of Technology.

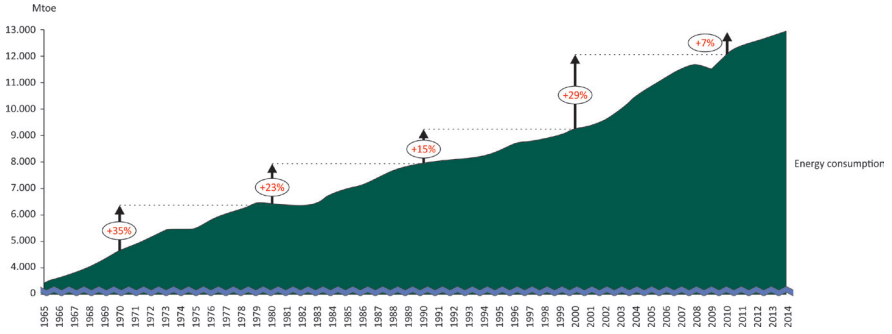
The Authors

CHAPTER ONE

Historical determinants of globalization of the LNG market

Natural gas is a hydrocarbon known to mankind for thousands of years. One of the earliest uses we know of was the construction of the temple in Delphi, at the place where natural gas leaking from a rock crevice fueled the flame that was said to inspire prophesies. The lack of public awareness about the sources of the gas flames resulted in many cultures attributing a divine nature to them. However, as early as about 500 BCE, the Chinese had learnt to take advantage of the potential of natural gas. Through a primitive system of natural gas transportation, they used it to heat water so as to separate sea salt[1]. The beginning of commercial activity connected with the extraction of natural gas dates back to the mid-19th century. Since then, the market has evolved, ensuring natural gas a growing share in the energy mix of the largest world economies.

Chart 1. Primary energy consumption in the years 1965–2014



Global economic development has accelerated the demand for energy products. As a result, the consumption of primary energy is continuously growing. Fifty years ago, in 1965, the combined consumption of primary energy was

[1] Portal NatrualGas.org, http://naturalgas.org/overview/history/ (accessed: 16.07.2015).

3,729 Mtoe[2], whereas in 2014, 12,928 Mtoe was used – the equivalent of almost 3.5 times the consumption level of 50 years ago. Chart 1 presents changes in primary energy consumption in the years 1965–2014 and differences between consumption in the last year of each decade and the year 2014.

The growing energy demand is a direct effect of economic growth. Increasing the scale of production processes has translated into greater global energy demands[3]. Fluctuations in annual changes in global gross domestic product[4] are accompanied by respective fluctuations of changes in primary energy consumption (see Chart 2). This phenomenon was clearly seen with respect to the global crisis at the end of the last decade.

Chart 2. Annual changes in gross domestic product and primary energy consumption in the years 1980–2014

Source: International Monetary Fund, BP Statistical Review 2015.

There has been only one period of global economy regression within the latest 35 years. It was in 2009, when gross domestic product decreased by 0.1%. However, in the analyzed period, the global economy was growing

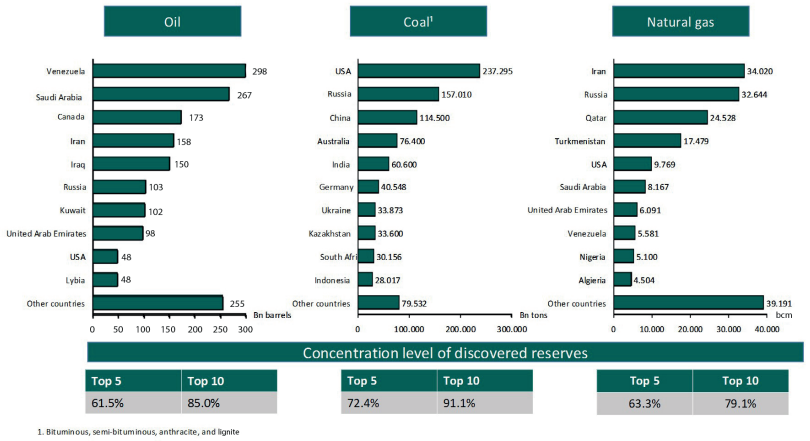
[2] Toe – *tonnes of oil equivalent* (energy unit approximately equal to 42 GJ).

[3] It should be noted that the growth of GDP in the analyzed period was faster than the growth of electricity consumption. This resulted from a lower demand for energy in order to generate an extra unit of GDP. In selected developed economies, such as Germany, Great Britain, or the USA, the peak of primary energy consumption is a thing of the past, and economic growth no longer directly translates into greater demand for primary energy. See *Can we sever the link between energy and economy growth?*, http://www.washingtonpost.com/blogs/wonkblog/wp/2014/01/17/can-we-sever-the-link-between-energy-and-growth (accessed: 20.07.2015);
An optimistic review, http://www.economist.com/blogs/buttonwood/2013/07/energy-use-and-growth (accessed: 20.07.2015).

[4] Real GDP, computed at a fixed exchange rate.

on average by 3.48% a year[5], which was accompanied by growth in primary energy demand by 1.92% year after year[6].

Chart 3. Concentration level of discovered resources of oil, coal and natural gas as of December 2014[7]



Source: Original study based on data from BP Statistical Review 2015.

The distribution of energy resources (especially hydrocarbons) in the world prevents most countries from satisfying their energy demands with domestic resources only. Five countries with the greatest resources of crude oil have nearly 62% of the global deposits of this fuel, and ten such countries, even 85%. The level of concentration of natural gas resources is similar. Five countries with the greatest resources hold more than 63% of global reserves, and the level of concentration in ten such countries exceeds 79%. Of the discussed renewable energy sources, the highest concentration occurs in the case of coal deposits. Ten countries with the greatest resources represent over 91% of global deposits.

[5] The level of resource concentration does not correspond to the level of production. The aim is to point out the uneven location of resources which can be profitably extracted using known technologies. In the case of oil production, in 2014 the concentration of production in the five countries that produced the most was 47.8%, and in the ten biggest producers, 66.4%. In the case of coal, concentration rates were 78.1% and 90.9%, and in the case of natural gas production, 52.6% and 67.2%, respectively.

[6] Arithmetic mean of annual changes in demand for primary energy in the light of data from BP Statistical Review 2015.

[7] Arithmetic mean of annual changes in global Gross Domestic Product See *World Economic Outlook. Uneven Growth Short- and Long-Term Factors*, International Monetary Fund, Washington 2015.

The uneven distribution of energy resources and the continuously growing demand for energy have caused a need for international trade in resources, fuels, and other energy products. Due to the great importance of hydrocarbons in global consumption of primary energy[8] (86.3% of primary energy consumption in 2014)[9], the volume of international trade is constantly growing[10].

Importing energy resources is a must for most countries nowadays. In 2014, only Russia out of the ten largest economies was a net exporter of all the described hydrocarbons in 2014. The largest world economy, the USA, had to import even 39% of the domestic demand for crude oil and 4% of natural gas, at the same time being a net exporter of coal. However, in that country the mix of fuels changed considerably as a result of the so-called shale revolution, which allowed it to increase the extraction of natural gas and decrease the domestic demand for energy coal[11]. The US has become the largest world producer of natural gas, with a share of 21.4% in 2014 (increased by 6.1% in comparison with 2013[12]). China has to import 62% of its oil, 6% of its coal, and 27% of its natural gas. The third largest economy in the world – Japan – is practically totally dependent on imported hydrocarbons. The demand for natural gas in Japan grew after the Fukushima nuclear accident in March 2011. Some European countries, being among the ten largest world economies, also display a high level of import dependence. Germany imports 100% of its oil, 89% of its natural gas, and 43% of its coal. France is only capable of meeting 1% of its domestic consumption demand for all these energy resources. Italy imports 90% of the consumed oil, 100% of coal, and 88% of natural gas. The situation in Great Britain is better. Its domestic production is enough to satisfy 57% of the country's demand for oil and 55% of that for natural gas. Great Britain imports 76% of its coal. In Brazil, imported oil accounts for 27% of consumption; in the case of coal, it is 79%, and natural gas, 49%. India is the third largest producer of coal in the world. Still, its huge internal demand means that 32% of coal must be imported. Besides, the country imports 37% of natural gas and 77% of oil[13].

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[8] M. Tamvakis, *Commodity Trade and Finance*, 2nd edition, Routledge, 2015, pp. 12–13

[9] Share of oil, coal, and natural gas, based on data from *BP Statistical Review 2015*.

[10] Global import of energy products from groups defined by the United Nations Conference on Trade and Development (UNCTAD) in the categories of energy product groups without electrical energy. The analyzed period involves year-on-year changes in the years 1996–2014. (accessed: 20.07.2015).

[11] A. K. Cohen, *The Shale Gas Paradox: Assessing the Impacts of the Shale Gas Revolution on Electricity Markets and Climate Change*, Harvard College Cambridge, 2013, pp. 3, 66–83.

[12] *BP Statistical Review of World Energy June 2015*, http://www.bp.com/content/dam/bp/pdf/Energy-economics/statistical-review-2015/bp-statistical-review-of-world-energy-2015-full-report.pdf (accessed: 21.07.2015).

[13] *BP Statistical Review 2015*; Portal *U.S. Energy Information Administration*, http://www.eia.gov (accessed: 21.07.2015).

Table 1. Dependence on the importation of energy resources in the 10 largest world economies in 2014[14]

Country	KB (bn US)	Import dependence		
		Crude Oil	Coal	Natural gas
USA	17.42	39%	-12%	4%
China	10.38	62%	6%	27%
Japan	4.62	100%	99%	96%
Germany	3.86	100%	43%	89%
Great Britain	2.95	43%	76%	45%
France	2.85	99%	99%	99%
Brazil	2.35	27%	79%	49%
Italy	2.15	90%	100%	88%
India	2.05	77%	32%	37%
Russia	1.86	-239%	-101%	-41%

Source: Original study based on data from *BP Statistical Review 2015, US Energy Information Administration*, IMF.

Global demand for energy resources has resulted in the need to work out models of transporting each of the resources in international trade. Due to the physical properties of hydrocarbons, the models differ. Oil has been transported over the sea, by rail, and via pipelines since the 19th century[15]. Because of its nature and known commercial applications, coal has long been transported over sea and along land routes. The industrial revolution of the 18th century stimulated the development of the use of coal in industry[16].

The development of large-scale transport of natural gas, however, took place much later. Because of its properties, for many years this material was only used locally. The turning point was the development at the end of the 19th century of technology for constructing up to approx. 160 km of leak-free gas pipelines running from upstream spots[17]. The 1920s and 30s were a time of construction of a natural gas system in the United States. But the popularity of natural gas as one of the key fuels in the world came 30 or 40 years later, when interest in natural gas increased. The global volume of gas consump-

[14] Import dependence defined as demand for the importation of a resource in relation to domestic consumption; data on the production of natural gas in France and Japan comes from U.S. Energy Information Administration. In 2013, the production in France was 12 bn cubic feet, and in Japan, 161 bn cubic feet. The coefficient of conversion into bcm is 0.028. There is no data for 2014; data on oil production in France, Japan and Germany comes from U.S. Energy Information Administration.

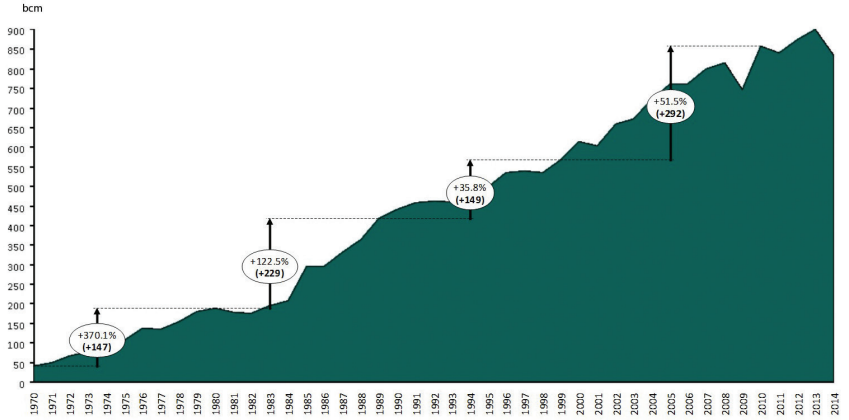
[15] M. S. Vassiliou, *Historical Dictionary of the Petroleum Industry*, Scarecrow Press, 2009.

[16] Portal *Encyclopeadia Britannica – Coa*l, http://www.britannica.com/science/coal-fossil-fuel (accessed: 24.07.2015).

[17] Ibidem.

tion in the years 1965–1975 rose by 83%. That was caused by events such as increasing the scale of production in countries with great deposits of natural gas, mainly the Soviet Union and the USA[18]; the first oil crisis, which made people aware of the need to have alternative energy technologies[19]; and the development of gas pipelines from Soviet sources of natural gas extraction, continued by Russia until now[20]. The 1970s was also the beginning of large-scale international trade in natural gas, which led to a significant increase in natural gas consumption in countries where its production either does not exist or is insufficient to meet the domestic demand for gas.

Chart 4. Excess of consumption over production in countries that import natural gas (1970–2014)[21]



Source: Calculated on the basis of *BP Statistical Review 2015.*

However, the system of gas pipelines was not enough to satisfy global demand for natural gas. Certain countries[22], which now import natural gas,

[18] *BP Statistical Review 2015.*

[19] Portal *Encyclopeadia Britannica*... op. cit.

[20] Portal *Gazprom*, http://www.gazprom.com/about/production/projects/pipelines/ (accessed: 25.07.2015).

[21] Due to missing information on some countries importing natural gas and the aggregation of information, it is impossible to precisely estimate the import level in such a long-term perspective. In particular, due to the existence of the Soviet Union and the lack of reporting, international trade between former Soviet republics was disregarded. Flows between countries aggregated to "other countries of the region" are not taken into account, either. In the analysis of more detailed information on international trade in the years 2000-2015, the difference between data on excess of consumption over production and the volume of international trade in natural gas does not exceed 15%.

[22] Primarily Japan and South Korea.

were isolated from the sources of supply because of their distance from natural gas producers or landform features that made it impossible to build a pipeline infrastructure. The solution to this problem was a system of transporting liquefied natural gas (LNG).

The history of the liquefaction of gaseous substances dates back to the end of the 17th century, when two French physicists[23] managed to liquefy sulfuric acid[24]. Other discoveries of the physicists led to the conclusion that for each gas there must be a temperature at which its liquefaction would no longer be possible regardless of the pressure (the so-called critical temperature). Two Polish scientists, Zygmunt Wróblewski and Karol Olszewski, also contributed to the study of liquefaction; they were the first to liquefy oxygen and nitrogen from the air and determined the critical temperatures of a number of gases[25]. More and more discoveries related to gas liquefaction led to the establishment of the world's first natural gas liquefaction installation, which became operable in 1917[26]. However, the first commercial installation was not built until 1941[27]. Discovering the technology of natural gas liquefaction opened the theoretical possibility of transporting it great distances. The technology of natural gas transportation by ship was patented in the 1920s by Godfrey L. Cabot[28]. In 1959, LNG was for the first time transported to another country over the sea, on "The Methane Pioneer" tanker, which left from Lake Charles in the US and arrived at Canvey Island in Great Britain[29]. That was the beginning of international trade in liquefied natural gas, which would soon achieve a significant share in international trade in natural gas. Exports of liquefied natural gas began in the 1960s. Discovering natural gas in Algeria and Libya, which are located much closer to Europe, as well as the awareness of a growing demand for natural gas, resulted in investments in export and import infrastructure. In 1964, the first supply of fuel from Algeria came to Great Britain. In the same decade, liquefied gas was already being supplied to Italy and Spain. The current biggest LNG importer, Japan, also emerged on the market then. The following decades were a period of new entities entering the market, both on the demand and the supply sides.

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[23] Gaspard Mongeoraz Jean Francois Clouet.

[24] J. Hrastar, *Liquid Natural Gas in the United States. A History*, McFarland, 2014, p. 87.

[25] Ibidem, p. 102

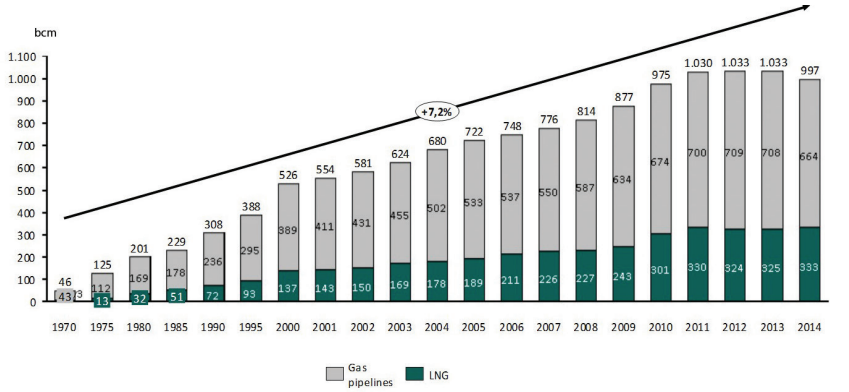
[26] *Liquefied Natural Gas Terminal Project*, http://www.kmtp.lt/uploads/Renginiai/Klaipeda%20LNG%20Forum%202011%2006%2016/LIQUIFIED%20NATURAL%20GAS%20TERMINAL%20PROJECT.pdf (accessed: 26.07.2015).

[27] Portal *2B1st Consulting*, http://www.2b1stconsulting.com/lng/ (accessed: 26.07.2015).

[28] M. D., Tusiani, G. Shearer, *LNG – A nontechnical guide*, 2007, p. XXI.

[29] Ibidem, p. 14.

Chart 5. International trade in natural gas in the years 1970-2014



Source: Calculated on the basis of Statista[30] *BP Statistical Review*[31].

The constantly growing demand for energy resources, including natural gas, and the existence of technology allowing the supply of natural gas to countries without any gas pipeline infrastructure, led to an increase of global trade volumes. In 1970, international trade in natural gas was only 46 bcm, with a 7% share of LNG. It is interesting, however, that more than 95% of consumption had its source in domestic fuel production. The following years brought an increase in international trade, its share in global fuel consumption, and in the LNG market. In 1980, the import of natural gas was 201 bcm, which accounted for 14% of global consumption. At the same time, the share of LNG trade in the total volume was already 16%. At the end of the next decade, over 300 bcm was imported, and 23% of that was liquefied gas. In 2000, global trade in natural gas was more than ten times higher than the trade of 1970. It accounted for 22% of global gas consumption, and even 26% of the trade volume was liquefied gas. The next decade was a time of considerable increase in the liquefied gas market. In 2000, 137 bcm was sold on international markets, yet by 2010, it was already 301 bcm. The LNG market was growing faster than the trade in pipeline natural gas. In 2010, more than 30% of global natural gas consumption was imported. In the discussed period, the annual average increment in volume was 7.2%[32].

International trade in natural gas was the result of a constantly growing demand for energy resources, closely associated with economic growth and the uneven distribution of deposits of energy resources and their pro-

[30] Portal *Statista*, http://www.statista.com/statistics/264000/global-lng-trade-volume-since-1970 (accessed: 25.07.2015).

[31] Editions 2005–2015.

[32] *Compound annual growth rate*.

Chart 6. Share of international trade in natural gas in global natural gas consumption in the years 1970-2014

Source: Calculated on the basis of Statista[33], *BP Statistical Review*[34].

duction all over the world. The development of technology for transporting natural gas in a liquefied form over the sea made it possible for countries that did not have the right conditions to invest in gas pipeline infrastructure to actually import the fuel. Consequently, not only did the import of natural gas become possible, but new sellers could also enter the market and markets became more competitive. The oil crises of the 1970s caused the need to diversify sources of primary energy, thus partly contributing to the popularization of natural gas. Development of the LNG market, in turn, has enable the diversification of natural gas supplies, ensuring greater energy security concerning the same fuel.

[33] Portal *Statista,* ... op. cit.

[34] Editions 2005–2015.

CHAPTER TWO

The European Union's LNG strategy

Liquefied natural gas is going to have long-term strategic importance for the European Union in terms of guaranteeing economic development and energy security. Therefore, EU member states are developing their energy infrastructure to ensure access to global LNG markets and allow each of them direct or indirect (via intermediate countries) access to supplies of liquefied natural gas from overseas. The use of such infrastructure will largely depend on current prices of the energy resource on world markets. The increase in LNG availability will entail an increase in competition on the gas market, and ensure market pricing of the resource. The price may possibly become lower, especially in the initial period. Therefore, it is in the European Union's interest to develop an energy infrastructure that will enable liquefied gas importation over the sea from any direction or source, and its flexible economic use[1]. At the same time, new installations will be constructed to enhance the use of liquefied gas as a fuel in road, rail, and maritime transport, and in local sources of heat and electricity generation. For this purpose, it is necessary to establish appropriate chains of supply of this resource. Environmental issues are also important. As a result of its production process, LNG is the cleanest of all fossil fuels in terms of emission of harmful substances to the atmosphere. LNG is produced by means of liquefaction of natural gas, during which gas is cooled and refined, especially from acidic gases as well as compounds of sulfur, water, and mercury[2]. Consequently, burning LNG causes lower emission of harmful substances (carbon dioxide, nitrogen oxides, sulfur dioxide, ashes, etc.) to the atmosphere. All this, combined with the growing flexibility of applications, makes LNG an important fuel in the economy. The aim of the chapter is to present the position of LNG in European Union policy. The directions of its activities will affect not only the EU energy market, but also world markets.

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[1] R. Zajdler, *Wzrośnie import LNG do Europy [LNG import to Europe is going to grow]*, "Puls Biznesu" of 23.12.2014

[2] Side products of this process, especially hydrocarbon compounds, are re-used in the process or used as commodities, e.g., LPG.

2.1. The importance of LNG terminals on the common EU energy market

LNG terminals play a significant role in the common EU energy market because they contribute to greater energy security and the development of competition, which ensures market pricing of the commodity in Europe. R. Dohms emphasizes that the functioning of the common EU energy market will be based upon free access to, and the flow of, energy resources and electricity[3]. Research by S. Dorigoni, C. Graziono and F. Pontoni shows that LNG exporters' access to the natural gas market will improve market competitiveness even in the case of higher prices of LNG supply than the supply of pipeline natural gas, but on condition that: first, new competitors enter the market; second, the spot market is developing[4]; third, costs related to LNG are going down[5]. The researchers also underscore the growing importance of spot transactions on the natural gas market, pointing out that they will play an important role in the liberalization of the EU energy market[6]. But on the other hand, the question arises as to whether the development of LNG terminals will contribute to integration or rather fragmentation of the natural gas market in Europe. Analyzing the development of the infrastructure of LNG terminals in the European Union, we can see that countries that have the most advanced installations for importing liquefied gas, e.g. Spain, France, Italy or Portugal, have the poorest interconnectors with neighboring countries (Great Britain is an exception). There is no gas connection between France and Italy. France and Spain have a connection with a very low throughput; flows between Spain and Portugal are very low, and the interconnector connecting their gas systems at Badajoz has its capacity contracted until 2035[7]. This may mean that the countries of the Iberian and Apennine Peninsulas intend to make their gas markets regional and are reluctant to extend their interconnections, out of fear of market competition. As a result, the development of LNG terminals may contribute to a lower pace of establishing a common EU energy market, and the phase

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[3] R. Dohms, *The development of a competitive internal energy market in the European Community, Connecticut* "Journal of International Law", vol. 9 (1994).

[4] The spot market involves immediate delivery.

[5] S. Dorigoni, C. Graziano, F. Pontoni, *Can LNG increase competitiveness in the natural gas market?*, "Energy Policy" 38(2010), pp. 7653–7664.

[6] Ibidem, p. 7664.

[7] *ACER/CEER Annual Report on the Results of Monitoring the Internal Electricity and Natural Gas Markets in 2011*, Agency for the Cooperation of Energy Regulators, Slovenia 2012.

of its regionalization may be longer. However, the global import capacity of LNG terminals in 2013 was utilized in 35%, and in Europe the ratio was lower than 25%[8]. On the other hand, in the face of a political crisis causing a disruption of supply from one of the main sources to Europe, the import potential of LNG terminals could be very valuable. Then, the number of entries to the gas system through LNG installations plus natural gas interconnections would enable the infrastructure to distribute the required amounts of the resource to the countries of destination. This shows that a geopolitical crisis would cause a completely different influence of LNG terminals on the integrating energy market and would increase the level of utilization of their import potential. In a stable political situation, LNG terminals will be used to the extent profitable from the perspective of its importers to EU countries. Thus, they form a strategic energy infrastructure, which should safeguard the diversification of EU sources of natural gas supply.

2.1.1. Liquefied gas in strategic EU documents

In February 2016, the European Commission presented the "EU strategy for liquefied natural gas and gas storage", which is an important element in ensuring the security and diversification of natural gas supplies[9]. Previous strategic documents underscored the need to increase energy security and diversify the direction and sources of natural gas supply. However, the EU had long ago seen the potential of liquefied gas, as in the document *European Energy and Transport Trends to 2030* issued in 2003: the European Commission forecast that LNG would play a significant role in the integration of regional gas markets[10]. In 2007, the European Commission presented another version projecting trends in the energy and transport sectors by 2030, and pointed out that the global LNG market was going to gradually develop over that time[11]. A forecast announced in 2014 emphasized that the develop-

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[8] M. Ruszel, *Znaczenie terminali LNG na wspólnym rynku energii UE [The importance of LNG terminals on common EU energy market]*, "Polityka i Społeczeństwo", no. 4(2014).

[9] *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on an EU strategy for liquefied natural gas and gas storage,* {SWD(2016) 23 final}, COM (2016) 49 final, Brussels, 16.02.2016.

[10] *European Energy and Transport Trends to 2030*, European Commission, January 2003, p. 13, https://ec.europa.eu/energy/sites/ener/files/documents/trends_to_2030.pdf (accessed: 9.07.2015).

[11] *European Energy and Transport. Trends to 2030 – update to 2007*, European Commission, April 2008, p. 28, https://ec.europa.eu/energy/sites/ener/files/documents/trends_to_2030_update_2007.pdf (accessed: 9.07.2015).

ment of LNG fuel in road transport required the extension of infrastructure in European countries[12]. In 2011, in its Communication to the European Parliament, the Council, the European Economic and Social Committee, and the Committee of the Regions, the European Commission emphasized the need to extend the connections between EU natural gas networks and third party countries by means of building new gas pipelines and LNG terminals[13]. It also pointed out the important impact of LNG on the global natural gas market and the need to begin political dialogue with new producers of liquefied natural gas[14]. The Regulation of the European Parliament and of the Council (EU) no. 347/2013 of 17 April 2013 on guidelines for trans-European energy infrastructure and repealing Decision No 1364/2006/EC and amending Regulations (EC) No 713/2009, (EC) No 714/2009 and (EC) No 715/2009, pointed out that "energy storage facilities and reception, storage and regasification or decompression facilities for liquefied natural gas (LNG) and compressed natural gas (CNG) have an increasingly important role to play in European energy infrastructure. The expansion of such energy infrastructure facilities forms an important component of a well-functioning network infrastructure."[15]. In the *European Energy Security Strategy* adopted in 2014, the European Commission underscored that LNG supplies would remain one of the key sources of diversification of natural gas supply to Europe[16]. The importance of liquefied natural gas was also emphasized in the project of the European Energy Union (EEU) presented in 2015. Then, the European Commission announced the beginning of work on the integrated strategy of LNG development in Europe. In July 2015, the European Union began public consultations concerning the working versions of

[12] *EU Energy, Transport and GHG Emissions. Trends to 2050*, Publications Office of the European Union, Luxembourg 2014, p. 41.

[13] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on Security of Energy Supply and International Cooperation, "The EU Energy Policy: Engaging with Partners beyond Our Borders", COM(2011) 539 final version, Brussels 7.9.2011, p. 6, http://eur-lex.europa.eu/legal-content/PL/TXT/PDF/?uri=CELEX:52011DC0539&from=EN (accessed: 10.07.2015).

[14] Ibidem, p. 12.

[15] Regulation of the European Parliament and of the Council (EU) no. 347/2013 of 17 April 2013 on guidelines for trans-European energy infrastructure and repealing Decision No 1364/2006/EC and amending Regulations (EC) No 713/2009, (EC) No 714/2009 and (EC) No 715/2009, OJ EU L 115/39.

[16] *European Energy Security Strategy* (2014), Communication from the Commission to the European Parliament and the Council, SWD(2014)330 final, COM(2014) 330 final, Brussels 28.5.2014, p. 15.

the EU strategy of using LNG and natural gas storage facilities within the framework of the EEU[17].

In that document it was highlighted that LNG would play a key role in the diversification and continuity of supply and would improve competitiveness on the gas market. The European Union should ensure all member states direct or indirect (via neighboring countries) access to LNG importation. Improved regional cooperation and more interconnectors will be necessary to achieve that. This will be especially important for Bulgaria, Croatia, the Czech Republic, Estonia, Finland, Hungary, Latvia, Romania, Slovakia and Slovenia, because so far those countries have not had any access to the LNG market. The European Union will need to improve the capacities of gas flow between the northern and southern part of Europe. Therefore, a list of common interest projects was announced, including projects connected with LNG. The document emphasizes that potential new suppliers of liquefied gas face barriers at the terminal level, concerning contracts for supply and access to gas transmission systems and storage facilities[18]. The barriers involve linguistic restrictions, complicated and lengthy licensing procedures, and restrictive storage obligations. Overcoming those barriers may contribute to the optimum utilization of LNG terminals. The EU also stresses that LNG is going to be an attractive alternative to existing fuels. Greater use in sea transport will be possible upon taking appropriate actions concerning the barriers connected with insufficient bunkering ability, the regulatory and legislative environment, and a gap in harmonizing standards at different stages of supply chains. Further, the document points out the strategic importance of storage facilities in ensuring energy security. As a result, in February 2016, the European Commission announced an "EU strategy for liquefied natural gas and gas storage".

2.1.2. LNG position in the model of integration of the common EU energy market

The model of integration of the common EU energy market assumes the expansion of an energy infrastructure allowing bidirectional and flexible exchange of energy resources and energy. The integrated market will function on the basis of market competition principles, established by a proper regulatory environment as a result of the processes of market liberalization. The wholesale market will play an important role, based on energy exchange mar-

[17] *Consultation on an EU strategy for liquefied natural gas and gas storage*, https://ec.europa.eu/energy/sites/ener/files/documents/LNG%20consultation%20-%20publication.pdf (accessed: 22.07.2015).

[18] Ibidem, p. 5.

kets and energy hubs. The model of integration of a common energy market must include a system of natural gas security based not only on neighboring countries[19]. This means that the LNG market is going to play an important role along with on-land and submarine pipelines and natural gas interconnectors, because it will ensure access to global natural gas resources. D.A. Wood highlights that LNG was incessantly developing in the years 1990–2010 at a global rate of 7.2% a year, and by 2020, the growth rate is going to be even higher[20]. Liquefied gas will play an important role in the model of the integrating market, as extra supplies of gas can begin quickly thanks to LNG terminals. If a long-term energy crisis occurs, where stocks of gas in underground natural gas storage facilities are used up, liquefied gas will be a reliable element of the security system[21].

LNG will become a real alternative to diesel oil and compressed gas, becoming a significant fuel in the sector of road, sea and air transport. Its advantage in road transport will continually grow, along with further restriction of environmental standards for burnt fuels. The situation will be similar to that of air or sea transport[22]. This is confirmed by the Directive 2012/33/EU of the European Parliament and of the Council of 21 November 2012 amending Council Directive 1999/32/EC as regards the sulphur content of marine fuels[23], which came into force on 1 January 2015. In accordance with that legal act, the sulfur content used by ships should not exceed 0.1% (previously, 1%). This is an opportunity for broader application of LNG fuel in sea transport. In northern European harbors, fixed LNG bunkering stations are being constructed. Ports in Stockholm are among the first in the world to offer bunkering ships with liquefied gas using the *vessel-to-vessel* method. In the Baltic Sea region, only Sweden offers bunkering with this fuel now; Poland is going to be the other country in the region to allow refilling ships with liquefied gas (the LNG terminal in Świnoujście). It is estimated that providing these services will be a significant source of income for service

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[19] R. Zajdler, M. Gałczyński, *Model wspólnego systemu bezpieczeństwa dostaw gazu ziemnego w Unii Europejskiej. Postulaty de legeferenda [The model of common system of security of natural gas supply in the European Union: de lege ferenda demands]*, "Polityka i Społeczeństwo", no. 4/12(2014), p. 40.

[20] D. A. Wood, *A Review and Outlook for the Global LNG Trade*, "Journal of Natural Gas Science & Engineering" vol. 9, November 2012, pp. 16–17.

[21] R. Zajdler, M. Gałczyński, *Model wspólnego systemu*..., op. cit., pp. 43-44.

[22] D. Leifheit, *LNG as a fuel: isolating «sweet spots» in demand*, http://www.naturalgas-europe.com/lng-as-a-transport-fuel-world-gas-conference-75839 (accessed: 17.07.2015).

[23] Directive 2012/33/EU of the European Parliament and of the Council of 21 November 2012 amending Council Directive 1999/32/EC as regards the sulphur content of marine fuels, OJ EU L 327 of 27.11.2012.

providers, including ports. This means that more legal acts are going to be issued as part of the integration model for a common EU energy market, favoring low-emission fuels (emitting fewer greenhouse gases) such as LNG. That is why the development of a liquefied gas market in Europe is based on the expansion of infrastructure enabling an efficient chain of transport and distribution of this fuel in each region and country.

2.1.3. The impact of LNG terminals on the security of gas supplies to the EU

LNG terminals play a significant role in the diversification of sources of natural gas supply, providing importers access to world markets. This is especially important for those EU countries that have already experienced the effects of disruptions in the natural gas supply caused by conflicts between Russia and Ukraine or Russia and Belarus. Liquefied gas terminals increase Europe's energy security by improving the stability of gas supply[24]. The *International Energy Agency* (IEA) emphasizes that LNG terminals are a protection against the risk connected with natural gas supply disturbances[25]. IEA has developed a model of evaluating energy security called *Model of Short-term Energy Security* (MOSES), emphasizing that LNG terminals are important points of entry to the gas system and that they make it possible to diversify the suppliers of natural gas[26].This means that the more opportunities a country has for importing gas, the more resistant it is to different disturbances in this area[27]. Among EU countries, supplies of liquefied gas are especially important for Spain which, thanks to a well-developed energy infrastructure that allows the import of natural gas via pipelines and LNG terminals, has the most diversified gas system in Europe: in 2014, it imported the resource from 11 different countries[28].

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[24] M. Tarnawski, *Rozbudowa infrastruktury gazowej a zwiększenie bezpieczeństwa energetycznego Polski dzięki dywersyfikacji źródeł i kierunków zaopatrzenia w gaz ziemny [Expansion of gas infrastructure vs the improvement of energy security of Poland thanks to the diversification of sources and directions of natural gas supply]*, [in:] "Analiza infrastruktury gazowej w Polsce z perspektywy przyszłych wyzwań energetycznych i rozwoju sektora gazu niekonwencjonalnego", Instytut Kościuszkowski 2013, p. 89.

[25] *World Energy Outlook 2014*, International Energy Agency, Paris 2014, p. 2, https://www.iea.org/Textbase/npsum/WEO2014SUM.pdf (accessed: 17.01.2015)

[26] J. Jewell, *The IEA Model of Short-term Energy Security (MOSES). Primary Energy Sources and Secondary Fuels*, International Energy Agency, 2011.

[27] M. Ruszel, *Znaczenie terminali LNG na...* op. cit.

[28] R.D. Ibarra, *LNG market development, spring seminar of the Finnish Gas Association*, 23.04.2015 Helsinki, http://www.maakaasu.fi/sites/default/files/pdf/esitykset/20150423_kevatkokous/Reganosa.pdf (accessed: 6.07.2015).

Actually, in the case of a geopolitical conflict which may cause political destabilization either in the country exporting natural gas via pipelines or in the transit country, the impact of LNG terminals on the security of gas supply to the European Union will be even greater. Analyzing the current world situation, we can point out that the risk of an armed conflict or political destabilization is most probable in Northern African countries and the Russian Federation. In the case of Russia, natural gas supplies are used by the country as an instrument for exerting political pressure on consumers in order to achieve some political ends[29]. As for the southern sources of natural gas supplies to Europe, we can see more and more competition between countries where considerable amounts of the resource have recently been discovered (e.g. Cyprus, Egypt, Israel, Lebanon, Syria, or Turkey), especially that both Algeria and Qatar intend to retain their position as stable suppliers of liquefied natural gas to the European Union. More countries that invest in the development of LNG export infrastructure (among others, the US, Canada, and Australia) are also interested in the European market.

2.1.4. The importance of LNG terminals in negotiating natural gas supplies

The development of the international market for liquefied gas has caused greater competitiveness between LNG exporters, who are fighting for end customers. As a result of discovering more confirmed natural gas deposits, the competition between countries has recently become increasingly fierce. More and more entities are emerging on world markets that offer supplies of liquefied gas, which has also led to constructing new gas liquefaction terminals. Globally, the main LNG exporters nowadays are: Qatar, Malaysia, Australia, Nigeria, Indonesia, Trinidad and Tobago, Algeria, Oman, and Yemen, and more countries are planning to build installations to be able to export liquefied gas. Therefore, competition between LNG exporters is growing, which may contribute to greater political tension and more armed conflict in different parts of the world.

Currently, in Europe, we can also see a fight for end customers between the exporters of pipeline natural gas and exporters of liquefied gas delivered over the sea via LNG terminals. This competition is beneficial from the point of view of the consumer, because it breaks the monopolistic practices some gas companies have applied on the European natural gas market. Besides,

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[29] Y. Fedorov, *Continuity and change in Russia's policy toward Central and Eastern Europe*, "Communist and Post-Communist Studies", vol. 46 September 2013, pp. 315–326.

it causes two price levels on the EU market: that of natural gas supplied via pipelines as part of long-term contracts, which is indexed to the prices of crude oil and oil derivatives, and that of natural gas as part of short-term contracts, increasingly indexed to wholesale market prices of natural gas[30]. Since 2008, the price of natural gas based on short-term contracts has been lower than the price of natural gas supplied as part of long-term contracts by the Russian Federation, Norway and Algeria, which apply the mechanism of indexing price to crude oil and oil derivatives[31]. This has contributed to initiating renegotiation of the price of natural gas supplied as part of long-term contracts indexed to the price of oil. Energy companies importing the material this way have begun to negotiate with the Russian exporter, Gazprom, which additionally employed abusive clauses in its long-term contracts. This means that LNG terminals significantly contribute to increased competition on the natural gas market, lowering the price of that resource on the European market as part of short-term contracts. The result is greater pressure in negotiations with suppliers that offer natural gas as part of long-term contracts.

Therefore, technical re-gasification potential is used as an instrument in negotiating gas contracts, both concerning supplies over the sea and via pipelines. From the point of view of a country importing natural gas, it is important to have an energy infrastructure that will lead to competition between different exporters. Countries that do not have the technical capabilities of importing natural gas from different sources and directions but are dependent on supplies from one source instead do not have great bargaining power in negotiation with the exporter. Furthermore, the exporter can then force the terms and conditions of the contract, for example, by exerting political pressure or threatening to stop supplies. Hence, it is in the interest of EU countries to expand their energy infrastructure and implement appropriate regulations to ensure the development of competition on the natural gas market. As the number of terminals in Europe grows, the competition will also increase, promoting changes in the EU market for natural gas. Most European countries have long-term contracts for natural gas supplies, and can renegotiate the terms and conditions of supply every 2 or 3 years, whenever market conditions change. Thus, an increase in LNG infrastructure expansion will improve the bargaining power of European countries in relation to previous suppliers of natural gas.

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[30] R. Zajdler, *Rynek hurtowy gazu ziemnego na tle rynków Unii Europejskiej [Wholesale market of natural gas against the background of European Union markets]*, Warsaw 2014, p. 44

[31] D. A. Wood, *A Review and Outlook*..., op. cit.

2.2. Strategic goals for the development of LNG infrastructure and the challenges to the distribution system

One strategic goal of the European Union is to expand its energy infrastructure to better use the potential of liquefied natural gas, because LNG is currently the highest-potential source of gas supply to Europe[32]. The existing and planned liquefied gas installations ensure the continuity of supply in an emergency situation. However, the distribution of gas imported over the sea is limited by the capacity of pipelines between countries with the greatest LNG import potential and other EU countries. Hence, the expansion of a natural gas transmission infrastructure could contribute to ensuring greater reliability of supplies to regions where supply over the pipelines may be disturbed. Countries of Central and Eastern Europe have the poorest LNG infrastructure. This causes greater risk of supply disruptions in the case of a geopolitical crisis, but in the case of political stability it potentially means lower competitiveness on the gas market, especially in the situation of insufficient two-way flow capacities at interconnections. That is why the European Union is striving to harmonize the development of energy infrastructure ensuring flexible transfer of energy resources, alternative fuels, and electricity.

Another goal of the EU is to build a network of stations for refilling LNG in sea ports by 2025 and in inland ones by 2030[33]. The stations are expected to include among others LNG terminals, tanks, mobile containers, bunker ships and barges[34]. EU member states should expand their LNG transmission networks and ensure a system of distribution between the storage facilities and liquefied gas refilling stations[35]. It is estimated that LNG refilling stations should be at least 400 km apart. The European Union intends to establish by 31st December 2025 a relevant number of publicly available LNG refilling stations within the TEN-T network[36]. The European Commission aims to reduce the use of oil in transport and at the same time to develop alternative fuels. That is why the *Roadmap to a Single European Transport Area* was adopted on March 28, 2011, so as to achieve a competitive and resource-ef-

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[32] Communication from the Commission to the European Parliament and the Council, on the short term resilience of the European gas system, COM (2014) 654 final, Brussels, 16.10.2014, p. 12, https://ec.europa.eu/energy/sites/ener/files/documents/2014_stresstests_com_en.pdf (accessed: 23.07.2015).

[33] Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructure, OJ EU L 307 of 28.10.2014, p. 7.

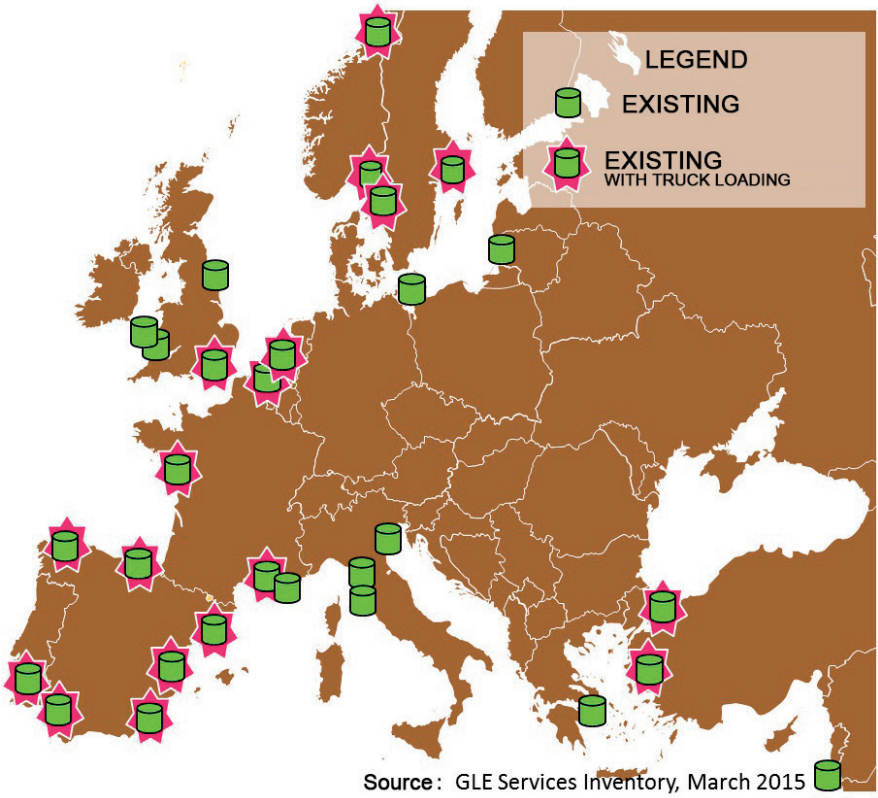
[34] Ibidem, p. 7.

[35] Ibidem, p. 4.

[36] Ibidem, p. 7.

ficient transportation system. To meet the assumed goals, considerable investment expenditure is necessary to expand liquefied gas infrastructure (including low-scale distribution), as its creation will have an impact on the speed of development of the LNG market in Europe.

Map 1: LNG import terminals with the possibility of truck loading



Source: Portal Gas Infrastructure Europe, http://www.gie.eu/index.php/maps-data/gle-sslng-map (accessed: 17.07.2015).

On the one hand, it is important to establish an appropriate chain of supply of this resource, and on the other, to improve the potential of import LNG terminals in terms of new services, i.e. reloading liquefied gas from terminal tanks to vessels or from one vessel to another, ship refueling, and loading into cryogenic containers on trucks or rail for further distribution[37].

[37] Portal Gas Infrastructure Europe, http://www.gie.eu/index.php/maps-data/gle-sslng-map (accessed: 20.07.2015)

Analyzing the potential of LNG infrastructure in Europe connected with the distribution of the material, we can see that the highest numbers of large and small gas installations are in Spain — 36, Norway — 35, Great Britain — 22, the Netherlands — 17, Sweden — 13, and France — 11 (see Table 2)[38]. As for plans to build new installations, Spain is planning 12 more, France 11, Sweden 10, and Great Britain and Germany, 9 each.

If these investment plans are carried out, Spain will have the most advanced LNG distribution network in Europe, and will become the leader in terms of LNG infrastructure development. Norway is not planning any more systems in the foreseeable future, while Germany, which does not have an LNG terminal and only has 5 installations at the moment, is planning to build 9 more. Thus, it intends to become one of the countries that participate in the development of the European LNG distribution system.

It seems that establishing an appropriate supply chain is the greatest challenge to the development of an LNG distribution system in Europe. R. Jokinen, F. Pettersson, and H. Saxen emphasize that an appropriate design for supply ensures savings in investment and operating expenses, and a typical low scale supply chain should include a large LNG import terminal, small LNG terminals, and a fleet of ships and trucks to transport liquefied gas[39].

2.2.1. LNG storage on the common market

Liquefied gas delivered to LNG terminals can be stored at liquefied gas storage facilities. These facilities are part of the so-called critical infrastructure, which should be properly protected from any threats[40]. LNG storage facilities are e.g. susceptible to a terrorist attack and sabotage, so these kinds of risk need to be taken into account at the planning stage. The ignition of LNG is possible when two circumstances occur at the same time: the temperature must be at least 540°C, and the amount of LNG in the mixture must be 5–15%. If these conditions are not met, LNG is non-combustible. High flash point and limited combustibility range make LNG quite safe. Thus, if LNG is spilt on the ground or on the water but does not meet a source of ignition with the temperature over 540°C, it mixes with air and evaporates. The flash point of other known substances is much lower, which increases the risk of ignition. The flash point of gasoline is 257°C, of diesel oil, 316°C, of ethanol,

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[38] *Small scale LNG Map 2015*, GIE, http://www.gie.eu/download/maps/2015/GIE_SSLNG_2015_A0_1189x841_FULL_wINFOGRAPHICS_FINAL.pdf (accessed: 23.07.2015).

[39] R. Jokinen, F. Pettersson, H. Saxen, *An MILP model for optimization of a small-scale LNG supply chain along a coastline*, "Applied Energy", 138(2015), pp. 423–424.

[40] J. M. Yusta, G. J. Correa, R. Lucal-Arantegui, *Methodologies and applications for critical infrastructure protection: State-of-the-art*, "Energy Policy", 39(2011), pp. 6100–6119.

423°C, of methanol, 464°C, and of LPG, 454–510°C. Still, potentially LNG is combustible, so it is necessary to keep all the protective procedures to minimize any risk[41]. All contemporary LNG tanks have double walls and are made of tested, choice materials. LNG storage facilities can be built underground and are accredited by the European standard confirming the safety of its storage (EN1473)[42]. They also have appropriate protections against terrorist attack, earthquake, or seismic activity[43]. The potential of liquefied gas tanks has a significant impact on the re-gasification capacity of an LNG terminal and may contribute to the development of services such as bunkering and reloading the gas on smaller vessels.

Table 2. Countries with the highest number of LNG installations (Europe top 10)

LNG installations in countries (The '10' list)	Number of LNG installations*		
	operating	under construction	planned
1. Spain	36	3	12
2. Norway	35	—	—
3. Great Britain	22	2	9
4. Netherlands	17	5	6
5. Sweden	13	—	10
6. France	11	4	11
7. Belgium	7	5	1
8. Germany	5	3	9
9. Portugal	4	1	4
10. Finland	2	8	5

* except storage facilities

Source: Portal Gas Infrastructure Europe, http://www.gie.eu/index.php/maps-data/gle-ssl-ng-map (accessed: 18.07.2015).

In the European Union, LNG storage tanks are located in Spain, Great Britain, France, the Netherlands, Italy, Portugal, Belgium and Greece[44]. Their combined potential is about 4.8 bcm natural gas. Spain has the largest storage

[41] A. Bernatik, P. Senovsky, M. Pitt, *LNG as a potential alternative fuel – Safety and security of storage facilities*, "Journal of Loss Prevention in the Process Industries", 24(2011), pp. 19–24.

[42] "LNG Safety and Security Aspects", [in:] *Handbook of Liquefied Natural Gas*, 2014, pp. 364–365, http://ac.els-cdn.com/B978012404585900009X/3-s2.0-B978012404585900009X-main.pdf?_tid=a2ec8d24-2abc-11e5-862a-00000aab0f6b&acdnat=1436942718_022ae33b9f1f3a40cdf44c95aa8f76fd (accessed: 15.07.2015).

[43] Ibidem, p. 365.

[44] Portal *Gas Infrastructure Europe*, https://lngdataplatform.gie.eu/index.php (accessed: 18.07.2015).

tanks, with a capacity of approx. 1.93 bcm natural gas[45]. The country with the second highest capacity is Great Britain (1.23 bcm natural gas), and the third, France (0.5 bcm natural gas). This means that the combined capacity of LNG storage tanks in Spain and Great Britain is 65% of the real capacity of the European Union. Globally, the real capacity of storage tanks in Spain and Great Britain is 7% and 4% respectively, so together they account for 11% of the world's capacity of LNG storage tanks[46]. Japan and South Korea have the greatest LNG storage capacities: 34% and 14% respectively[47]. LNG tanks are created directly at LNG terminals and are an important element that allows the optimum use of the resource.

From the point of view of integrating the energy market of the European Union, LNG tanks are not going to play a role similar to that of traditional underground natural gas storage facilities (UGS). The difference primarily results from the difference in potentials. UE–28 has a combined UGS capacity of 91.3 bcm natural gas, whereas the total capacity of LNG tanks is 4.8 bcm. This means that the capacities of liquefied gas storage tanks account for about 5% of the total capacity of natural gas storage in the European Union. Therefore, LNG tanks should not be perceived as systems that ensure storage of natural gas for critical situations. Instead, they are the infrastructure used for holding LNG so as to ensure the proper functioning of LNG terminals and first of all, a secure re-gasification process. However, in future we must expect the development of a network of liquefied gas tanks as the demand for LNG fuel in sea and road transport grows. That is why local storage facilities should be established to enable proper distribution of liquefied gas near refilling stations for vehicles, rail, ships, and for the generation of electricity and heat.

2.2.2. European LNG trading hubs

European Union member states can import 490 bcm natural gas a year via pipelines, and 197 bcm using LNG terminals[48]. Currently, Spain, France,

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[45] Calculated on the basis of data from Aggregated LNG Storage Inventory ALSI, http://lngdataplatform.gie.eu/ (accessed: 15.07.2015). Available data (as of 12.07.2015) shows that the declared maximum potential of LNG tanks, i.e. so-called DTMI, is 8.17 million m³ LNG (mcm = 8.178 10³ m³ LNG). The value of 8.17 million m³ LNG was multiplied by 0.5875 to receive a value in bcm.

[46] *World LNG Report – 2014 Edition*, IGU, p. 36, http://www.igu.org/sites/default/files/node-page-field_file/IGU%20-%20World%20LNG%20Report%20-%202014%20Edition.pdf (accessed: 26.07.2015).

[47] Ibidem, p. 36.

[48] Communication from the Commission..., op. cit., p. 2.

Portugal and Great Britain have the best technical capabilities for importing liquefied gas. The share of LNG in total gas consumption varies from country to country. In Spain and Portugal it is about 50%; in the Netherlands, less than 3%. Countries of Central and Eastern Europe do not have any access to LNG import except the newly established LNG terminal in Lithuania[49]. The establishment of a liquefied gas trading hub is conditional on having sufficient energy infrastructure. In Europe, Spain, Great Britain, Sweden, the Netherlands, France, and Norway (which is not part of the EU) have the most developed LNG infrastructure. Those countries not only have LNG import terminals, but they also have systems that enable small-scale distribution of the resource used in maritime and road transport. LNG trading hubs in Europe will not only necessitate the expansion of LNG infrastructure, but they will also require sufficient capacity of pipelines or road and railroad chains of gas distribution. Thus far, so-called gas hubs have been established in Europe. These are points for the physical offtake of gas, mostly located at the crossing of pipelines to enable the flow of gas in different directions, or virtual hubs, covering part of the natural gas transmission system[50]. There are three types of gas hub: trading hubs, transit hubs, and intermediate hubs[51]. Together with energy exchanges, they are the main places of making transactions on the European wholesale market.

Analyzing the situation in Europe, we can see that liquefied gas trading hubs may be established in Great Britain, which has the advanced National Balancing Point (NBP) and a well-developed energy infrastructure; in Spain, which has many LNG terminals but would need to enhance the capacity of the interconnector with France; in Sweden, which has well-developed LNG infrastructure, including ship infrastructure; in France, which has great potential LNG installations and extensive interconnectors with neighboring countries (except the Netherlands and Italy – no interconnections with those countries); as well as in the Netherlands, Belgium, and Italy. It is worth pointing out that in 2011 an LNG re-gasification terminal was established in Rotterdam, which improved competitiveness in relation to Dutch gas delivered via pipeline to Germany and Great Britain[52]. In this way, Rotterdam

[49] Ibidem, p. 1.

[50] R. Zajdler, *Perspektywy rozwoju formuł cenowych w kontraktach długoterminowych na dostawy gazu ziemnego oraz ich znaczenie dla stworzenia w Polsce hubu gazowego dla państw Europy Środkowo-Wschodniej [Perspectives of development of pricing formulas in long-term contracts for natural gas supply and their importance for the establishment of a gas hub in Poland for Central and Eastern European countries]*, Warsaw 2012, p. 76.

[51] P. Heather, *Continental European Gas Hubs: Are they fit for purpose?*, The Oxford Institute for Energy Studies, 2012, pp. 5–20.

[52] D. A. Wood, *A Review of Outlook*..., op. cit., pp. 22–23.

became an important gas hub for the north-western part of the European Union. This does not mean, however, that natural gas trading hubs cannot be established in other parts of Europe. Portugal, Finland, and Germany plan to increase their LNG installations. In Central and Eastern Europe, Poland has the potential to become the regional LNG trading hub for that region. Not only the development of an LNG terminal, but also the use of collaboration potential within the Visegrad Group and Eastern Partnership, and the development of a Polish Power Exchange, would be vital.

2.2.3. Financing the development of LNG infrastructure in Europe

Projects connected with the construction or modernization of LNG infrastructure may be subsidized with EU funds if they receive the status of *Projects of Common Interest* (PCIs). By virtue of Regulation of the European Parliament and of the Council (EU) no. 347/2013 of 17 April 2013 on guidelines for trans-European energy infrastructure, the European Commission pointed out that "projects of common interest should comply with common, transparent and objective criteria in view of their contribution to the energy policy objectives"[53]. Annex no. 1 to the Regulation identified the priority corridors and energy infrastructure areas, including priority gas corridors. Hence, PCIs that contribute to the construction of infrastructure corridors in the EU may be subsidized from EU resources.

Within the financial framework for the years 2014–2020, a new financial facility was created: the *Connecting Europe Facility* (CEF), oriented at supporting the development of infrastructure in transport, energy, and telecommunications. CEF was established on 19th October 2011 by virtue of Regulation of the European Parliament and of the Council establishing it[54]. In accordance with the specific goals of the energy area, CEF is to support further integration of the energy market as well as gas and electricity networks, improve the security of natural gas supplies, and contribute to sustainable development and environmental protection. The value of subsidies for energy projects within the framework of this facility in the 2014-2020 period is to be approximately 5.85 bn euros. CEF has replaced the former financial instrument, Trans-European Transport Network (TEN-T). On Octo-

[53] Regulation of the European Parliament and of the Council (EU) no. 347/2013 of 17 April 2013 on guidelines for trans-European energy infrastructure and repealing Decision No 1364/2006/EC and amending Regulations (EC) No 713/2009, (EC) No 714/2009 and (EC) No 715/2009, OJ UE L 115/39 of 25.04.2013.

[54] Regulation of the European Parliament and of the Council establishing the Connecting Europe Facility, COM(2011)655, Brussels, 19.10.2011, http://ec.europa.eu/budget/reform/documents/com2011_0665_pl.pdf (accessed: 17.07.2015).

ber 14, 2013, the European Commission announced a list of 248 PCIs which were assigned to 12 regional groups for the 2013–2015 period. The list will updated every two years. To qualify as a PCI, a project must bring significant benefits to at least two EU countries and support the development of energy market and carbon dioxide emission reduction. So far, many projects connected with liquefied gas have been granted EU resources. In 2013, 14 LNG projects were financed as part of TEN-T[55], and the 34 projects subsidized in 2014 included e.g.: an LNG terminal on the Croatian island Krk, an LNG terminal in Greece, and the FRSU*(Floating Storage and Regasification Unit)* Aegean[56]. On July 14, 2015, member states approved the European Commission's proposals for granting CEF funds in the first contest announced in 2015, amounting to 159 million euros[57]. The following projects connected with liquefied gas were granted subsidy: Finngulf LNG (Finland), Krk LNG (Croatia), Zlobin-BosiljevoSisak-Kozarac-Slobodnica LNG (Croatia), and a gas connection between Italy and Malta, involving an FRSU. The second project collection period was finished on October 14, 2015. In 2016, there were three collection periods, finished on April 28, 2016, November 8, 2016, and December 13, 2016, respectively. The next collection period is scheduled in 2017.

2.2.4. Regional importance of LNG[58]

An important aspect of the regional significance of LNG is the European Union's dependence on external sources and directions of natural gas supply. Yet, the importance of terminals in different parts of the EU is varied. While in the West, e.g., in France, Italy, or Great Britain, sea LNG receiving terminals ensure greater competition with suppliers of pipeline gas, in Central Europe (e.g., in Poland and Lithuania) their construction is mostly

[55] *14 LNG projects to receive TEN-T funding, including NGVA members Rolande LNG, Fluxys and Wärtsilä*, http://www.ngvaeurope.eu/14-lng-projects-to-receive-ten-t-funding-including-ngva-members-rolande-lng-fluxys-and-waertsilae (accessed: 18.07.2015). The complete list of LNG projects with the subsidized amount is available on the website: http://www.ngvaeurope.eu/downloads/news/TEN-T_2013_LNG_List_upload_final.pdf (accessed: 18.07.2015).

[56] *List of actions selected for receiving financial assistance under CEF-Energy as of 21 November 2014*, https://ec.europa.eu/energy/sites/ener/files/documents/20141121_cef_energy_lists.pdf (accessed: 23.07.2015).

[57] Project of common interest, http://ec.europa.eu/energy/en/topics/infrastructure/projects-common-interest (accessed: 21.07.2015).

[58] A large part of this section was originally published as an article: P. Turowski, *Bezpieczeństwo dostaw gazu dla Grupy Wyszehradzkiej i pozostałych państw Unii Europejskiej [Security of gas supplies to the Visegrad Group and other EU countries]*, "Bezpieczeństwo Narodowe" quarterly, BBN, no. 30(2014), pp. 111–131.

Table 3. Natural gas import dependence of EU countries in 2013

Country	Import dependence
Austria	84%
Belgium	100%
Bulgaria	94%
Croatia	34%
Cyprus	N/A
Czech Republic	98%
Denmark	-56%
Estonia	100%
Finland	100%
France	99%
Greece	100%
Spain	100%
Netherlands	-85%
Ireland	96%
Lithuania	100%
Luxembourg	100%
Latvia	100%
Malta	N/A
Germany	88%
Poland	72%
Portugal	100%
Romania	15%
Slovakia	98%
Slovenia	100%
Sweden	100%
Hungary	82%
Great Britain	50%
Italy	89%
EU-28	66%

Source: Eurogas (as of the end of 2013).

connected with ensuring diversification of sources of natural gas supply. Yet, it is a great political, legal, and administrative challenge to adapt terminals designed to improve the security of national markets to the challenges of regional energy security. These design and conceptual problems are visible e.g. when looking at the shape of regions for the purpose of ensuring countries' energy security. In accordance with Annex 1 to the Regulation of the European Parliament and of the Council (EU) No. 994/2010 of 20 October 2010 concerning measures to safeguard the security of gas supply and repealing Council Directive 2004/67/EC[59], Germany is included in three gas regions (with the north-western European countries, with the Czech Repub-

[59] OJ EU L 295 of 12.11.2010, p. 1.

lic and Slovakia, and with Poland). This shape of regions for collaboration in critical situations could hamper the actual utilization of the LNG terminal in Świnoujście to support the countries that are under special threat. The Świnoujście terminal would play a role in enhancing the security of Germany, but its significance for Central and Eastern European countries would be lower. The region proposed by the ENTSOG, in turn, is very large, covering Germany, Poland, Austria, the Czech Republic, Slovakia, Croatia, Romania, and Bulgaria[60]. The area is heterogeneous, as it includes both countries with a relatively high level of security in the natural gas sector and many countries with poor diversification, strongly dependent on supplies from the Russian Federation. Really safeguarding security in such an area may require greater integration of the European Union market[61]. This shows that building regional collaboration in critical situations did not always involve fully effective utilization of the available infrastructure.

In the context of regional importance of the LNG terminal in Świnoujście, the Visegrad Group project, i.e., collaboration between the Czech Republic, Poland, Slovakia and Hungary, also plays a role. Building wholesale market mechanisms and collaboration in critical situations will depend, among others, on the construction of new interconnectors and the introduction of regulatory changes facilitating the development of the common market of gas supply. From the systemic point of view, elements that are necessary to implement this concept are the building of the North-South gas pipeline axis between these four countries, and the establishment of new points of gas supply. The Polish LNG terminal in Świnoujście, located at the upper point of the designed axis, may enhance the energy security of the region in the future. But the establishment of a crisis security system should be accompanied by the development of market collaboration mechanisms. The Visegrad Group countries differ in terms of their level of dependence on external natural gas supplies. However, the difference in diversification of sources and directions of natural gas supplies to Western Europe and Central and Eastern Europe is evident. Within the European Union, regional initiatives have been taken to ensure security and improve competition in the natural gas supply sector.

The section of the North-South gas corridor from Poland to Hungary is to be commissioned by 2018[62]. The new gas axis will connect four gas mar-

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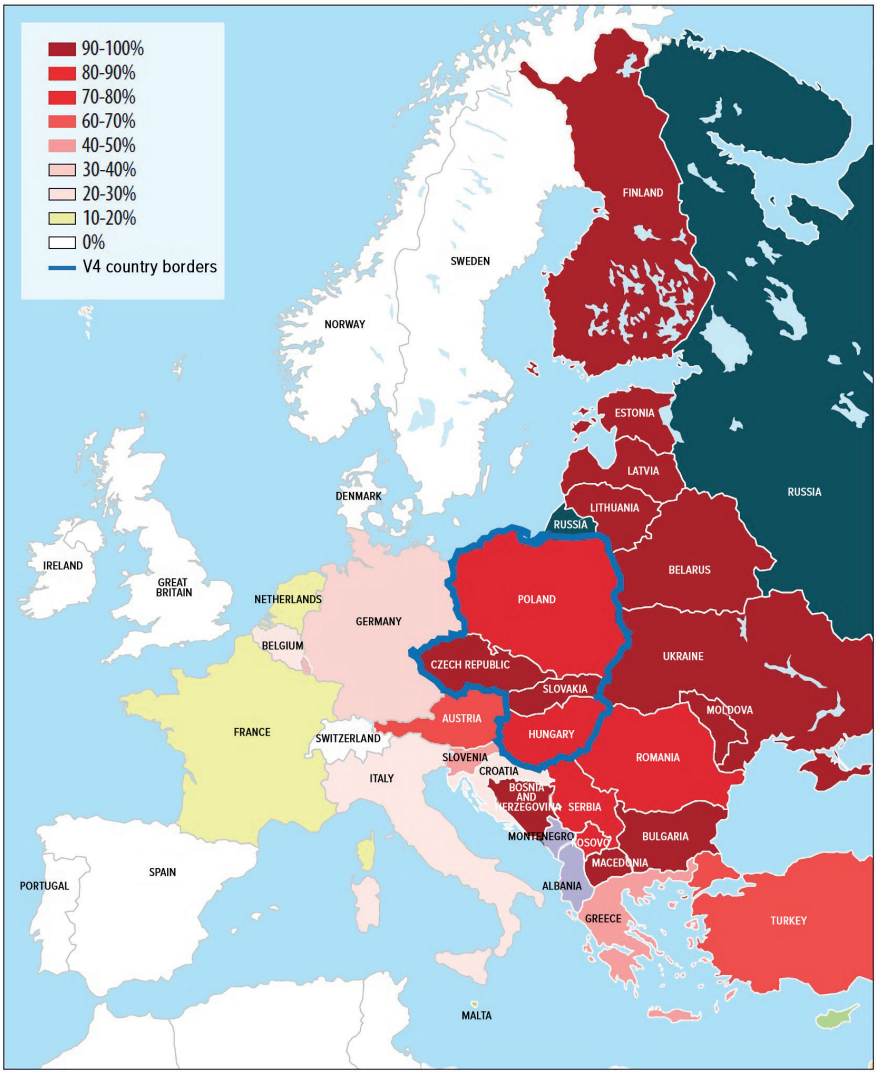
[60] *Gas Regional Investment Plan 2014–2023*, Central Eastern Europe GRIP, Main Report, ENTSOG.

[61] Some specialists of the energy market even point out that the area is too big to be transformed into a regional market in the future.

[62] *Road Map towards a Regional Gas Market among the V4 Countries*, Warsaw, 16.06.2013, http://www.visegradgroup.eu/documents/official-statements (accessed: 16.03.2014).

Map 2: Dependence of European Union countries and Turkey on natural gas supplies from the Russian Federation



Source: P. Turowski, *Bezpieczeństwo dostaw gazu dla Grupy Wyszehradzkiej i pozostałych państw Unii Europejskiej [Security of gas supplies to the Visegrad Group and other EU countries],* "Kwartalnik Bezpieczeństwo Narodowe", no. 30 (2014), BBN, Warsaw 2014, p. 113, https://www.bbn.gov.pl/pl/wydarzenia/5731,Kwartalnik-quotBezpieczenstwo-Narodowe-nr-30quot-25-lat-polskiej-strategii-bezpi.html (accessed: 03.08.2015).

kets with an annual gas import demand of approx. 30 bcm[63]. This shows the importance of regional investment in the development of common security. The regional significance of the LNG terminal in Świnoujście may also change. Although Visegrad Group countries are among others engaged in the same energy projects in the area of diversification of natural gas supplies, they differ in their level of determination in carrying out the investments. In the political and economic circles of Slovakia and the Czech Republic there is a common belief that V4 has great transit importance for Russian gas. It is pointed out that the largest transmission gas pipeline from Russia to Germany runs through Slovakia and the Czech Republic. Including the Yamal pipeline running through Poland, V4 countries transmit at least 100 bcm of Russian gas. It is argued that in Slovakia there is a huge pipeline which allows the technical possibility of transmission of approx. 90 bcm of gas a year from the East, so despite the forecast of a reduction in transmission (as a result of the commissioning of the NordStream pipeline and diverting some of the gas to the submarine main), only the transit of Russian gas can ensure the profitability of the existing infrastructure. Gas trading along the North-South axis or from the West to the East will not be able to compensate for revenues gained previously. This is one reason why Slovakia is preparing the Eastring project, which may be a route for Russian gas from Turkey to Central Europe. In the Czech Republic, extra sources of security for the gas supply are being sought through good integration of the Czech and German transmission systems. The Opal pipeline running from the coast of the Baltic Sea to the Czech Republic as an overground branch of NordStream is treated as a way to enhance energy security. Hungary, the chief supporter of construction of a North-South corridor, after suspending the Nabucco-West project and the LNG terminal at the Adriatic Sea is concentrating more and more on collaboration with the Russian Federation in the energy sector. Therefore, another possible scenario is that the North-South gas axis will not diversify supplies but instead distribute Russian gas from SouthStream to other countries of the Visegrad Group. Although this will definitely not happen soon, still it is possible. That is why the return to projects for providing the V4 Group with Azerbaijani gas (along the route of the so-called South Energy Corridor) and construction of a liquefied gas receiving terminal in Croatia would restore the original significance of the North-South corridor. A single LNG terminal on the Polish coast will still strengthen Poland's energy security rather than the other countries of the Visegrad Group, even after expansion.

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[63] *BP Statistical Review of World Energy June 2013*, http://www.bp.com/content/dam/bp/pdf/statistical-review/statistical_review_of_world_energy_2013.pdf (accessed: 17.03.2014).

Map 3: North-South Gas Axis and the planned sources of gas supplies

Source: P. Turowski, *Bezpieczeństwo dostaw gazu dla Grupy Wyszehradzkiej*... op. cit., p. 118.

But regional initiatives are not always given the priority they should be given. Although there are four projects for new gas sources, only one (the Świnoujście terminal) is currently being implemented. The Nabucco West project has been withheld due to the selection of another course of gas transmission, i.e. the Trans Adriatic Pipeline, transmitting gas via Greece to southern Italy. There is little probability that the LNG terminal on the Croatian coast of the Adriatic Sea will be built in the foreseeable future, despite its status as a project of common interest[64]. The terminal was designed to provide up to 6 bcm of gas, both to satisfy domestic demand and for delivery to other countries. Deposits of natural gas were discovered in the country's

[64] *Projects of Common Interest in Energy of 14.10.2013*, http://ec.europa.eu/energy/infrastructure/pci/doc/2013_pci_projects_country.pdf (accessed: 19.03.2014).

shelf[65], and the beginning of extraction has become a priority. The AGRI project (Azerbaijan-Georgia-Romania-Interconnector[66]) was also unlikely to be implemented from the beginning, since its main originator, Azerbaijan, treated it as an alternative to the priority overground gas pipeline. When the construction of TAP (Trans Adriatic Pipeline, designed to transmit Azerbaijani gas from the Turkish border, through Greece, up to southern Italy) was agreed to, work on AGRI was no longer justified. That is why the North-South gas corridor has no alternative to Russian sources in the southern part.

As for investment in the Świnoujście LNG terminal, the decision for its construction, including the current technical parameters (re-gasification capacity of 5 bcm a year with possible extension up to 7.5 bcm) was officially announced in 2006[67]. The LNG terminal was assumed to play a key role in reducing Poland's dependence on gas supplies from the Russian Federation, and it was forecast that after completion of the investment, approximately 30% of domestic demand would be covered by liquefied gas supplies. A two-way submarine gas pipeline called the "Baltic Pipe", connecting Poland and Denmark, was also planned. It was designed to export any potential surplus of gas from the LNG terminal to the Danish (in future, also the German) market. So in the original concept, the LNG terminal was to diversify natural gas supplies to the domestic market by fostering competition, and to enable the sale of the gas on European Union markets. However, over time the form of the project evolved, and all administrative action was aimed at establishing a new formula for further implementation of the investment[68]. The stimulus to actually begin work on construction of the LNG terminal was the gas conflict between the Russian Federation and Ukraine in January 2009, which resulted in withholding the transit of Russian gas to many countries of the Balkan region and Central Europe (including Poland). As

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[65] Chorwacja odkryła duże złoża gazu i ropy *[Croatia has discovered large gas and oil deposits]*, Wirtualny Nowy Przemysł of 21 January 2014, http://nafta.wnp.pl/chorwacja-odkryla-duze-zloza-gazu-i-ropy,216440_1_0_0.html (accessed: 15.03.2014).

[66] *Project Overview*, http://www.agrilng.com/agrilng/Home/DescriereProiect (accessed: 16.03.2014).

[67] Resolution of the Council of Ministers no. 3/2006 on measures aimed to diversify energy carriers of 3 January 2006 and Resolution no. 77/2006 of 31 May 2006, in which the Council of Ministers found the construction of an LNG terminal by PGNiG SA to be compliant with the government's policy, and entrusted the monitoring of the works to the Minister of Economy.

[68] Resolution of the Council of Ministers no. 167/2008 on measures aimed to diversify natural gas supplies to Poland. The resolution made it possible to transfer the company responsible for the terminal from PGNiG to OGP Gaz-System, which enabled further implementation of the project. On December 8, 2008, Gaz-System acquired 100% of shares in Polskie LNG Sp. z o.o.

a result of the crisis of January 2009, the government announced a plan of activities to improve energy security; one of its pillars was construction of the LNG terminal in Świnoujście with the expansion of the national transmission system. In April 2009, a special purpose act[69] was adopted that made it possible to move the investment forward. The decision to resume work was also affected by changes in the global LNG market, which gave extra market impulse to the investment. This shows regional activity that is making use of global trends to introduce an element that improves security in the region. However, for the action to be effective, stable political decisions are necessary at the regional level and in the whole European Union – which is not always the case.

2.2.5. Perspectives of development of the LNG market by 2030

It is in Europe's interest to increase the security of natural gas supplies by achieving the goals of a diversification policy for supply sources. As a result of an unstable geopolitical situation, especially in the face of political instability in northern Africa and conflict between Russia and Ukraine, the European Union is striving to enhance the reliability of natural gas supplies in a critical situation. According to the *European energy security strategy* adopted in May 2014, despite previous accomplishments in diversifying natural gas supplies, the European Union is still at risk of external energy crises[70]. The strategy emphasizes that LNG is going to remain a primary and increasingly important source of diversified natural gas supplies to Europe[71]. The document also points out that North America, Australia, Qatar and newly-discovered deposits of the resource in Africa will improve the liquidity of world LNG markets[72].

The LNG market is expected to develop in a stable way over the next few decades. International organizations dealing with the energy sector emphasize that the development of unconventional natural gas will significantly affect the dynamics of growth of the LNG market[73]. This confirms the impact of the dynamics of the shale gas revolution in the US on the decision to initiate activities creating a regulatory environment and to expand energy infrastructure that would enable the transport of American gas over the sea.

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[69] Act of 24 April 2009 on investments concerning the LNG re-gasification terminal in Świnoujście, Journal of Laws of 2014, item 1501.

[70] Communication from the Commission to the Council and the European Parliament: European energy security strategy. SWD(2014) 330 final, Brussels 28.5.2014, p. 2.

[71] Ibidem, p. 18.

[72] Ibidem, p. 18.

[73] D. A. Wood, *A Review and Outlook*..., op. cit., pp. 17–18.

An important factor that has led to the increased significance of liquefied gas supplies over the sea is new discoveries of natural gas in the Baltic Sea Region (Cyprus, Egypt, Greece, Israel, Lebanon, Syria, and Turkey) and a constant decrease of gas extraction in the Netherlands, which used to be a reliable source of gas supplies to the EU market. This means that the level of EU countries' dependence on imported natural gas may grow in future as the extraction of this resource in the Dutch Groningen deposit decreases[74]. Then, Europe will face the dilemma of whether to enhance over-the-sea delivery through LNG terminals or to contract greater amounts of Russian natural gas, since its supplies may be increased without the need to invest in the extension of energy infrastructure. Reduction in the volume of Dutch gas production will result in competition between exporters of pipeline natural gas and those exporters that use LNG terminals in terms of contracting the supply of certain amounts of the resource. From the perspective of EU countries, the competition between suppliers will be beneficial, because it will make it possible to choose a supplier that guarantees stable gas supplies without the political risk and at an acceptable price, contributing to greater competitiveness of the European industry. As climate-based standards get stricter and stricter, the significance of liquefied natural gas as a fuel used in transport will continue to grow. LNG terminals will play an important role on the natural gas market, as they will contribute to greater flexibility in natural gas trading, which will lead to lower prices of the resource on world markets. As a result, the prices of pipeline gas will drop.

[74] In 2013, the Netherlands extracted 53.8 bcm natural gas, and in 2014, 42.5 bcm. It is estimated that in 2016, the amount of extracted natural gas will be around 30-40 bcm per annum. This amount of natural gas will be enough to satisfy the demand of the Netherlands, but will have a detrimental effect on export capabilities. So far, the country has sold gas to Germany, France, Great Britain and Italy. The situation may result in higher flow rate of natural gas through the Nord Stream pipeline to Western Europe via the NEL. See A. Kublik, *Holandia ogranicza wydobycie gazu. Wielka szansa dla Gazpromu [The Netherlands to reduce gas extraction. A great opportunity for Gazprom]*, http://wyborcza.biz/Energetyka/1,129200,15306000,Holandia_ogranicza_wydobycie_gazu__Wielka_szansa_dla.html (accessed: 25.06.2015). Cf.: D. Saygin, W. Wetzels, E. Worrell, M.K. Patel (2013), *Linking historic developments and future scenarios of industrial energy use in the Netherlands between 1993 and 2040*, Energy Efficiency, vol. 6, no. 2, 2013, pp. 341–368.

CHAPTER THREE

The Regulatory environment

The above-mentioned strategic activities of the European Union and political determination has resulted in the discussed regulatory solutions concerning the LNG market. Originally, liquefied natural gas had no special place in EU law. It was regulated by principles concerning the establishment of an internal European Union market and common rules of competition. However, the primary law of the EU did include some indirect references to that market. The issues connected with its functioning are more thoroughly regulated in the secondary law of the European Union. The analysis concentrates on the legal solutions that affect the position of this fuel and further prospects for its development, disregarding significant but less strategic important legal solutions concerning e.g. technical aspects. Analyzing the solutions of national law, the emphasis is on Poland's strategic documents and legal solutions influencing the availability of the fuel on the market, the possibility of developing LNG technology and its role in the economy and in ensuring the security of the state. In the final part of the chapter, further directions of legislative changes are mentioned, which may have an impact on broader applications of the fuel in the economy.

3.1. Legal and regulatory determinants of LNG market in the EU

Regulations of EU primary law

Regulations of EU primary law do not directly refer to the LNG market or liquefied natural gas as a fuel. A number of legal regulations therein have been the legal framework for the market[1]. The energy sector has been the object of EU regulations from the very beginning. Both the Treaty establishing the European Coal and Steel Community[2] and the Treaty establishing the

[1] A. Lorkowski, M. Nowacki, *Traktatowe uwarunkowania rozwoju polityki energetycznej UE [Treaty-based determinants of the development of EU energy policy]*, [in:] "Nowa Europa Przegląd Natoliński" I/8 (2009), Warsaw 2009, p. 183.

[2] Portal EUR-Lex, http://eur-lex.europa.eu/legal-content/FR/TXT/PDF/?uri=CELEX:11951K/TXT&from=PL (accessed: 17.07.2015).

European Atomic Energy Community[3] directly regulated issues connected with the energy market. The Treaty establishing the European Economic Community[4] included general principles on the functioning of the uniform market of the contemporary European Union and the applicable rules for competition. As explained in its Preamble, one objective of the community was "to eliminate the barriers which divide Europe" so as "to guarantee steady expansion, balanced trade, and fair competition". These objectives were to be achieved by: the abolition of obstacles to the free movement of goods and services, a common competition policy, and the approximation of legislations of Member States to ensure the functioning of the Common Market (Article 3). These regulations have been in force to this day, supplemented with a number of detailed legal solutions. Later changes in EU primary law introduced additional regulations resulting from the competence division between Member States and the European Union[5].

An important regulation introduced by another treaty – the Single European Act (1986) – was gradual integration of the EU common market as an area without internal barriers, ensuring the free flow of goods, services, capital, and persons. The integration was to be complete by December 31, 1992. The Treaty also introduced a new significant policy, important from the point of view of the LNG market, i.e. policy concerning the natural environment. Besides, the Treaty facilitated economic integration of EU Member States by enabling the introduction of regulations to harmonize the internal market (such as legislation packages referring to natural gas) by a qualified majority, instead of the previously binding unanimity in the Council. This was to help preserve, protect, and improve the quality of the environment, and ensure prudent and rational utilization of natural resources (Article 25). Those regulations only indirectly apply to the issue of LNG, as one of the their objectives is to ensure the rational utilization of energy resources, but they do not specifically refer to LNG.

In 1988, the European Commission decided to work out a document concerning the Internal Energy Market[6]. The belief was expressed in the document that competition should become the main factor in the process of integrating the energy market based on the application of general European Union law principles. Competition should play a greater role in the

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[3] Consolidated version of the Treaty establishing the European Atomic Energy Community, OJ EU of 30.03.2013 C 84/1.

[4] EUR-Lex, http://eur-lex.europa.eu/legal-content/FR/TXT/PDF/?uri=CELEX:11957E/TXT&from=PL (accessed: 16.07.2015).

[5] K. Lenaerts, P. Van Nuffel, *European Union Law,* third edition 2011.

[6] Commission Working Document on an Internal Energy Market [COM(88)232 (1988)].

process of integration, and state intervention in energy markets should be limited to whatever was needed to ensure the security of supply and meet climate targets – an element of environmental protection. In order to avoid extra costs to consumers or disturbances in the functioning of its internal market, the European Union assumed that public intervention in the energy market should be planned "with great care". Elements of this approach can be noted in the regulations of European Union secondary law (e.g. liberalization packages for the natural gas market), which exclude crucial elements of gas infrastructure, i.e. LNG terminals, from the application of some rules of the internal market.

Changes in the expansion of gas infrastructure were effected by the Maastricht Treaty (1992)[7], which introduced a policy concerning trans-European networks into the law of the European Union. Pursuant to Article 129b of the Treaty, the community was designed to enable citizens "to derive full benefit from the setting up of an area without internal frontiers" and to "contribute to the establishment and development of trans-European networks in the areas of transport, telecommunications, and energy infrastructures" (in the energy sector, so-called "TEN-E"). The development of power networks was to promote interconnections, access, and interoperability of domestic networks. The objective of that policy was to support transport connections, mainly to strengthen operational collaboration between national networks and enhance their accessibility. The development of TEN-E had great significance for the functioning of the internal energy market. It ensured a higher quality of services and greater choice of natural gas suppliers as a result of the diversification of sources of natural gas. TEN-E played the key role in ensuring supply security and diversification. The Treaty also supplemented the provisions of the natural environmental policy. Pursuant to Article 130(r) section 3 of the Treaty, the policy on the environment should be prepared with consideration of the economic development of the Community as a whole, thus striving to eliminate different approaches to the issue of *energy mix* by ensuring greater unification. This direction of changes of European Union law made it easier to implement LNG technology as a new element of the infrastructure, enabling the diversification of sources and directions of natural gas supplies and environmental protection.

The goal of another treaty, the Treaty of Amsterdam (1996)[8], was to enhance economic integration. From the point of view of development of LNG regulations, it is vital that a high level of environmental protection was attributed to have great importance as one of the principles mentioned

[7] OJ EU C 224 of 31.08.1992, pp. 1–79.

[8] OJ EU C 340 of 10.11.1997, pp. 1-144.

in Article 2 of the Treaty, and had to be included in all policies and activities of the EU (Article 6).

It was only the changes finally introduced by the Lisbon Treaty (2009), i.e. among others the Treaty on European Union (TEU)[9] and the Treaty on the Functioning of the European Union (TFEU)[10], that confirmed the significance of the energy market in European Union policy[11]. The Treaty on the Functioning of the European Union introduced a separate energy policy as compared to the primary law of the European Union. In accordance with Article 194 of TFEU, "in the context of the establishment and functioning of the internal market and with regard for the need to preserve and improve the environment, Union policy on energy shall aim, in a spirit of solidarity between Member States, to: (a) ensure the functioning of the energy market; (b) ensure the security of energy supply in the Union; (c) promote energy efficiency and energy saving and the development of new and renewable forms of energy; and (d) promote the interconnection of energy networks."[12] The provision assumes support for actions aimed to ensure supply security thanks to LNG terminals. It also assumes supporting mutual connections between energy networks. So far, the latter aspect has mostly been discussed from the point of view of expanding interconnectors. The question is, however, to what degree it should also refer to LNG terminals. Apart from interconnections, such infrastructure ensures supplies of natural gas from out of the territory of the member state. It can also be used to deliver gas within the member state in the case of a complex structure of LNG terminals and limited transport (transmission and distribution) network. LNG terminals combined with logistic infrastructure (e.g. tankers) may serve a function similar to that of interconnectors.

In accordance with EU assumptions, the uniform natural gas market was to begin its functioning in 2014[13]. Its original structure was to be based on the

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[9] Consolidated text of OJ EU C 115 of 9.05.2008, p. 13.

[10] Consolidated text of OJ EU C 115 of 9.05.2008, p. 45.

[11] R. Zajdler, *Legal Aspects of Electricity and Gas Interconnectors with Third Countries*, [in:] *EU Energy Law, Legal constraints with the implementation of Third Liberalisation Package*, ed. R. Zajdler, Cambridge Scholars Publishing 2012.

[12] J. F. Braun, *Polityka Energetyczna Unii Europejskiej w świetle postanowień traktatu lizbońskiego między nową polityką a pozostawieniem «wszystkiego po staremu» [Energy policy of the European Union in the light of provisions of the Lisbon Treaty: between a new policy and 'leaving evertything as it was']*, [in:] "Nowa Europa Przegląd Natoliński" I/14(2013), Warsaw 2013, p. 188.

[13] Conclusions of the European Council of 4 February 2011; Communication from the Commission: Delivering the internal electricity market and making the most of public intervention, Brussels, 5.11.2013, C(2013) 7243 final, pp. 2-4.

framework regulations of EU primary law, solutions included in the so-called third liberalization package of the natural gas market[14], and technical solutions unifying different elements of the market, such as so-called network codes. The solutions are supplemented with regulations connected with supply security in critical situations and with market transparency. The solutions adopted in all of them are to ensure the gradual integration of national markets through regional solutions, up to full unification at the EU level[15].

Regulations of EU secondary law – the model of natural gas market liberalization vs LNG

The framework regulation concerning LNG is the Directive 2009/73/EC of 13 July 2009 concerning common rules for the internal market in natural gas, and repealing Directive 2003/55/EC[16], which is part of so-called third liberalization package[17]. The goal of the regulations is to provide a legal framework for the transmission, distribution, supply, and storage of natural gas, so as to ensure the development of a competitive market, eliminate internal barriers, and facilitate market access. They also provide for the principles of regulatory and control interference in the market. The analyses carried out for the purpose of those regulations[18] show that the wholesale and retail market were still highly concentrated, information provided by transmission system operators was insufficient, and the principles of ensuring capacity and managing limitations were not transparent enough. The above-mentioned regulation is expected to counteract such phenomena[19]. Regarding

[14] Directive 2009/73/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in natural gas and repealing Directive 2003/55/EC, OJ EU of L 211 of 14.8.2009, pp. 94–136; Regulation (EC) No 715/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for access to the natural gas transmission networks and repealing Regulation (EC) No 1775/2005, OJ EU L 211 of 14.8.2009, pp. 36–54.

[15] R. Zajdler, *Rola giełd energii w procesie budowania jednolitego unijnego rynku dnia bieżącego i rynku dnia następnego energii elektrycznej [The role of energy exchanges in the process of building a uniform EU energy intraday market and day-ahead market]*, "Humanities and Social Sciences" 4/2014, Oficyna Wydawnicza Politechniki Rzeszowskiej.

[16] OJ EU L 211 of 14.8.2009, pp. 94-136.

[17] K. Iwicki, A. Wawrzynowicz, *Podmioty odpowiedzialne za inwestycje w modernizację i rozbudowę infrastruktury gazowej w Polsce [Entities responsible for investments in modernization and expansion of gas infrastructure in Poland]*, [in:] "Analiza infrastruktury gazowej w Polsce z perspektywy przyszłych wyzwań energetycznych i rozwoju sektora gazu niekonwencjonalnego", Instytut Kościuszki 2013, p. 43.

[18] Status Review of the Liberalisation and Implementation of the Energy Regulatory Framework, ERGEG 2010, C10-URB-34-04, of 7.12.2010.

[19] R. Stankiewicz, *Wdrożenie rozwiązań trzeciego pakietu liberalizacyjnego dotyczących sektora gazowego w prawie polskim [Implementing the solutions of the third liberaliza-*

LNG, the provisions regulate the term 'LNG installation', its operator, and principles of functioning. When discussing the definition of 'supply', Article 2 item 7 of Directive 2009/73 differentiates between the sale (including resale) of natural gas and sale (including resale) of LNG. LNG is treated as a separate fuel, and the trade in it is regulated by this legal act. Apart from this separate definition, few specific provisions in the directive refer exclusively to LNG. However, it may influence further market development as soon as LNG technological advancement makes it possible to establish an autonomous trade model.

The other issue regulated separately is the definition of LNG installations. They are treated as a part of the gas system designed for liquefaction or re-gasification, except for LNG transport. In addition to liquefaction and re-gasification, it provides services connected with storage, buffering, and auxiliary services. Yet storage tanks are treated narrowly, only covering the surfaces that are necessary for the process of re-gasification and the delivery of gas to the transmission system, but not the part of the installation used for storing natural gas. Such installations are covered by another definition of storage. The regulation was designed to ensure the transparency of these two types of activity and the possibility of cost verification for the purpose of prices and fee setting, and to prevent cross-subsidy. It seems, however, that in terms of greater efficiency of operation of the installation, it would be appropriate for the definition to include natural gas storage installation used to improve the flexibility of introducing gas into the network or enhance trade flexibility for gas suppliers who use LNG installations.

Such an installation is administered by the LNG system operator. The regulation is very limited, leaving more specific regulations to national laws. Pursuant to Article 12 of Directive 2009/73, member states are obliged to appoint LNG system operators for a specified period of time. This can be done by state administrative act or by creating regulations to oblige the owner of LNG installation to do so. The entity appointed as the operator must ensure efficiency. These issues were regulated before in Article 7 of Directive 2003/55. The decision of the member state is the most important, and each state has the discretionary right to appoint one or more LNG operators within its territory. LNG operators appointed this way must act upon the requirements specified in Article 13 of Directive 2009/73[20]. The operator may not only be appointed administratively; gas enterprises owning

tion package concerning the gas sector in Polish law], [in:] "Nowe Prawo Energetyczne", Wydawnictwo KUL, Lublin 2013, p. 193.

[20] See Commission Staff Working Paper, Interpretative Note on Directive 2009/73/EC concerning common rules for the internal market in natural gas, Third-Party Access to Storage Facilities, Brussels, 22 January 2010, p. 6.

LNG installations may also be required to appoint the operator themselves. Pursuant to national law, this decision is to be approved by public administration bodies. On the one hand, appointing the operator for a specified period of time stabilizes the activities of operators. On the other hand, it gives national regulatory bodies additional opportunity for ex-post control of their obligations. Because of a number of aspects of the activity, important for ensuring competition and non-discrimination (access to the system, capacity management, limitations management, tariffs, the range of services, etc.), it seems right to introduce such verification mechanisms. Activity connected with LNG is market-oriented. Due to systemic (tasks connected with the functioning of the gas system) and geographical determinants (the distribution of such installations depends on regional conditions), leaving the whole system to competitive market mechanisms could have a negative impact on system security. On the other hand, administrative appointment of operators could fail to take into consideration the actual needs and directions of market development. Hence, the adopted concept in practice assumes the priority of administrative decision in appointing operators, but the decision should depend on purposefulness, so competitive market elements (such as efficiency or economic calculation) should be implemented in that sector, too.

The Directive also regulates the categories of tasks of LNG system operators (Article 13 of the Directive). The tasks include safeguarding ongoing activity, and if the market requires it, to develop installations, ensure non-discrimination, especially for the benefit of affiliated enterprises, provide other operators with information ensuring security and effective utilization of mutually connected systems, and provide users with information necessary for effective access to systems. These matters are specified both in Regulation 715/2009 and in national regulations, network codes, and national network operation and maintenance manuals.

Pursuant to Article 15 of Regulation 715/2009, LNG installation operators are required to provide services suited to market demand and to collaborate using interconnection capacities. The capacities should be equally available to all market participants. Market participants are to be adequately informed among others of the use and availability of the services offered. Limitations have been introduced concerning the application of prices and charges higher than in the approved tariff, even in the case of specific contractual terms. Financial guarantees for market participants were allowed. And pursuant to Article 17 of the Regulation, LNG installation operators should offer market participants the maximum capacity of the installation. Mechanisms of allocation of the capacity should be flexible, transparent, and ensure effective use by the market. The provision obliges LNG operators to offer the unused capacity on the primary market and to allow market participants to offer

it on the secondary market. Transparency requirements were introduced (Article 19), obliging LNG installation operators to provide market participants with clear information concerning services offered, contractual terms and conditions, technical requirements, as well as contracted and available capacities. There is also a requirement to prepare the tariff so as to enable market participants to calculate their payables themselves. Third party access is regulated, too (Article 15). LNG operators are expected to offer services on non-discriminatory conditions, with consideration of market demand, publicly announcing data concerning the use and availability of services, including the temporal framework compliant to the users' commercial needs. This is a framework regulation, indicating task categories rather than specific tasks. The objective of the regulation is to ensure the unification of basic tasks of LNG terminal operators, and to enable unification and price comparability. In order to ensure the transparency of an ongoing task, an LNG operator shall in particular establish and announce the procedures for using the installation, and the tariffs. In their ongoing activity, they should try to ensure the maximum utilization of the LNG terminal capacity. The principles of transparency and non-discrimination mean the public should receive the following information: information on the services offered and the conditions for providing them, technical information needed for effective access to the system, periodical information in accessible and normalized form on the contracted amount and available capacity, information on the amount of gas in each installation, on injected and re-injected amounts, on available capacity, and on installations exempt from third party access. The information should be provided in a clear, understandable and accessible form on non-discriminatory principles.

The principles of third party access to the LNG system are an important element of regulation. Pursuant to Article 32(1) of Directive 2009/73, LNG installation access shall be regulated (rTPA). This means that the enterprise should publish tariffs with charges and prices for the services. The tariffs, in turn, should be approved by the national regulatory office. Tariffs shall apply to all the entitled consumers and suppliers. They shall be transparent and non-discriminatory.

From the point of view of market development, Article 36 of Directive 2009/73 is important, as it regulates the exemptions from certain requirements of the Directive (Articles 9, 32, 33, 34 and 41 sections 6, 8 and 10) for new significant gas infrastructure, such as LNG terminals. Investment risk connected with infrastructure investments is difficult to estimate and reflect in tariffs, which negatively impacts the development of new investments. Therefore, it was necessary to guarantee to investors who chose certain infrastructure investments a greater and more stable source of income than

a fully liberal and competitive gas market could ensure[21]. However, approving this special investor treatment is dependent on a number of conditions regulated in that provision. The exemption may be applied to the existing infrastructure if its capacity significantly increases, and to changes in the existing infrastructure that allow development of new sources of gas supply. In the case of LNG terminals, the exemption involves third party access to the LNG terminal and principles for determining fees for its services. Based on the foregoing regulations, a number of terminals in the EU were exempted[22]. Analysis of these exemptions shows that they were granted for a specific period of time and combined with additional limitations of capacity subject to exemption. Furthermore, open tender procedures had to be carried out to check if there was really not enough market demand for a terminal's services, leading to the release (so-called "open season" market analysis). Some requirements were also introduced concerning auctions for long-term reservation of capacities[23]. Exemptions were to be better incentives to such investment, guaranteeing improved supply security and greater supply flexibility.

One of the goals of the provision is to develop mechanisms of solidarity on the natural gas market and to strengthen regional collaboration (Articles 6-7 of the Directive). Solidarity is related to ensuring secure and stable supplies of natural gas, especially in critical situations. It should be both regional[24] and

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[21] See H. M. de Jong, J. C. van der Lippe, H. P. A. Knops, *Investment in cross border transmission capacity: Economics or Politics?*, A European Case Study, Delf University of Technology, The Netherlands 2007; *Merchant transmission investment in Europe: opportunities for private initiatives in a regulated market segment*, ed. H. M. de Jong, H. P. A. Knops, IAEE International Coference, Potsdam 2006; A. Spanjer, *Do TPA Exemptions Solve The Hold-Up Problem on European Gas Markets?*, "ZeitschriftfürEnergiewirtschaft", vol. 32, no. 1, 2008, pp. 46–51.

[22] See A. De Hauteclocque, N. Ahner, *«Opt-out» Clauses for EU Energy Islands in the Third Liberalization Package: Striking Balances?*, EUI Working Paper RSCAS 71/2012; European Regulators' Experience with Article 22 exemptions of Directive 2003/55/EC; 2008 Update of ERGEG's internal survey, Ref: E08-GIF-02-03 z 10.03.2009.

[23] See *Guidelines for Good Practice on Open Season Procedures (GGPOS)*, Ref: C06-GWG-29-05c, ERGEG of 21.05.2007; *Draft Guidelines on Article 22*, An ERGEG Public Consultation Paper, Ref: E07-GFG-31-07, ERGEG of 5.03.2008, p. 8; *European Regulators' Experience with Article 22 exemptions of Directive*, Ref: E08-GIF-02-03, ERGEG 10.03.2010; R. Zajdler, *Legal Aspects of Electricity and Gas...* op. cit.

[24] Regional solidarity did not play a significant role in the European Commission's original concept (COM(2007)0529). The importance of regional solidarity was emphasized in the work of the European Parliament (2007/0196(COD)), in the opinion of the Committee of the Regions (CDR0021/2008), and of the Council (14540/2/2008). Its role in the establishment of internal market was recognized, see: Communication from the Commission to the Council and the European Parliament, Report on progress in creating the internal gas and

bilateral. Its importance in the context of the LNG market is connected with the role of LNG in ensuring stable and secure natural gas supplies. Regional determinants are of special importance. LNG terminals may be an alternative way of obtaining gas fuel on competitive principles. The issue of the importance of LNG in ensuring supply security was specified in Regulation (EU) No 994/2010 of the European Parliament and of the Council of 20 October 2010 concerning measures to safeguard security of gas supply and repealing Council Directive 2004/67/EC[25]. Regional collaboration is regarded as a way of creating internal market of natural gas in the EU[26]. The establishment of models of gas market functioning within regions is expected to improve integration between states. Integration between regions is the next step. EU internal market is expected to develop in a twofold way: both *top-down* and *bottom-up*. Thus, collaboration within regional markets, previously voluntary, has recently been normalized[27]. Currently, regulatory activities that integrate LNG infrastructure as part of natural gas supply to different regions are an element of regional collaboration. This occurs e.g. in the Iberian Peninsula, Scandinavia, and in the future it is also expected in Central and Eastern Europe[28].

Regulations of EU secondary law – a model for ensuring gas supply security vs LNG

European Union legal regulations concerning the security of natural gas supplies are made more specific in Regulation 994/2010. In accordance with the document, safeguarding a secure and stable natural gas supply is the responsibility of public authorities and energy enterprises. The basic mechanism for ensuring security is competitive market mechanisms based on the internal EU gas market. The obligation laid down by the regulation is fulfilled through market and non-market measures, both on the supply and

electricity market, COM(2010)84 final, 11.03.2010, pp. 5–7.

[25] See E. Klimowicz, *Rozporządzenie o bezpieczeństwie dostaw gazu – ocena skuteczności Parlamentu Europejskiego w realizacji Krajowej Strategii Legislacyjnej [Regulation on gas supply security – evaluation of the European Parliament's efficiency in the implementation of the National Legislation Strategy]*, [in:] "Nowa Europa Przegląd Natoliński" I/14(2013), Warsaw 2013, p. 213.

[26] See S. E. Beyer, *Developing a competitive European energy market: The infrastructural challenge*, [in:] M. Roggenkamp, O. Woolley, European Energy Law Report IX, Oxford 2012; D. Johnson, C. Turner, "Strategy and policy for Trans-European Networks", New York 2007.

[27] M. Swora, *Polska w procesie integracji europejskich rynków regionalnych [Poland vs the process of integration of European regional markets]*, „Rynek Energii", no. I/V(2010), p. 8; *Regional initiative Progress report: Safeguarding the move to the single EU energy market*, ERGEG, November 2009.

[28] R. Zajdler, *The future of gas pricing in long-term contracts in Central Eastern Europe. Global market trends versus regional particularities*, Warsaw 2012.

the demand side. Market measures on the supply side include the capacity of LNG terminals. Improper functioning of those mechanisms may lead to applying non-market measures.

The activities of public authorities are either preventive measures or crisis responses. Prevention is connected with the need to establish preventive action plans. Crisis responses are based on plans developed by each state in case of an emergency. The plans are then consulted with regional authorities and with the European Commission. Preventive action plans take into account the potential of supply through LNG terminals, both in terms of capacity and time of delivery, and in terms of diversification of sources and directions of supply. Crisis response plans diagnose the possibility and time frame of using different elements of the infrastructure, introducing some obligations for energy companies and natural gas consumers. The plans also refer to LNG terminals, whose flexibility and diversification potential may improve the efficiency of crisis measures.

Apart from action plans, the Regulation associates supply security with the proper level of development and functioning of the gas infrastructure. That is why a so-called infrastructure standard was established on the basis of N-1 indicator and two-way flow through interconnectors. The N-1 indicator is a statistical indicator showing whether in the case of disabling the single largest unit of the infrastructure (e.g., a gas pipeline, an LNG terminal, a source of gas production, or a gas storage facility) the remaining infrastructure will be able to ensure continuous and stable supply. The analysis is based on actual data concerning the infrastructure potential and gas demand on the day of demand peak, statistically occurring once every 20 years. The maximum technical capacity of LNG terminals is also taken into account. As for interconnectors, the Regulation assumes two-way operation based on constant capacity at all existing and new interconnectors. Article 6 section 5a of the Regulation makes an exception for the connection of the transmission network and LNG installation, pointing out that at such a connection two-way flow may not be possible. The exception may also be the result of the current level of development of the installations. Introducing such two-way operation would make sense on the condition of the existence of re-gasification/liquefaction terminals, which may be an element of infrastructure enabling the transfer of natural gas from one gas system to another not through the transport network but e.g. using tankers. Such solutions in the operation of terminals are currently rare. Ultimately, we can expect the development of technology in this respect and the existence of floating liquefaction and re-gasification terminals, which will make the two-way operation possible in practice.

The Regulation also introduces a so-called supply standard, i.e. the level of certain parameters of supply guaranteed in critical situations for so-called

protected consumers. Member states autonomously determine which consumers qualify as protected apart from residential ones. A state may apply this to small and medium-sized enterprises connected to the distribution network, entities providing social services (if those entities combined do not account for more than 20% of the final consumption of natural gas). The term may also apply to heating system installations if they deliver thermal energy to private consumers, small and medium-sized enterprises, and social service entities, unless they are able to use other fuels. Thus, the provision may be applied to installations using LNG for the needs of specific final consumers in terms of providing electricity from LNG, natural gas from LNG, or heat from LNG installations, so as to guarantee them continuous functioning.

The discussed Regulation does not include many references to LNG. On the basis of analyses performed by the European Commission[29], an amendment to the Regulation is planned, aimed to introduce more effective mechanisms of common preparation to critical situations and crisis response[30]. In the context of work on a new EU regulation concerning this area, LNG flexibility and potential should be given more attention, because they allow the continuity of supply and a high level of diversification. However, it is impossible to start using all sources of supply in a short time. Extra LNG transport will never arrive as quickly as natural gas from mandatory stock. On the other hand, spot LNG supplies are never-ending, while the amount of e.g. strategic reserve is bound to constantly decrease.

3.2. Legal determinants for establishing Poland's energy policy

Pursuant to Article 12 of the Energy Law Act of 10 April 1997[31], one of the tasks of the minister in charge of economic affairs[32] is to prepare the energy policy of Poland and coordinate its implementation. When carrying

[29] Communication from the Commission to the European Parliament and the Council on the short term resilience of the European gas system. Preparedness for a possible disruption of supplies from the East during the fall and winter of 2014/2015 (COM(2014)654final); Commission staff working document, Report on the implementation of Regulation (EU) 994/2010 and its contribution to solidarity and preparedness for gas disruptions in the EU; Communication from the Commission to the European Parliament and the Council on the short term resilience of the European gas system, Preparedness for a possible disruption of supplies from the East during the fall and winter of 2014/2015 (SWD(2014)325final)

[30] Zajder R., Gałczyński M., *Model wspólnego systemu bezpieczeństwa dostaw gazu ziemnego...* op. cit., pp. 35–49.

[31] Journal of Laws of 2012, item 1059 consolidated text as amended, hereinafter referred to as ELA.

[32] Pursuant to the Act of 4 September 1997 on government administration branches (Journal of Laws of 2015, item 812, consolidated text.

out such tasks, the minister is responsible in part for planning and security of fuel and energy supply and the necessary cooperation of central and local public administrative bodies, as well as coordinating cooperation with international government organizations[33].

Pursuant to Article 13 of ELA, the objective of the state energy policy prepared by the minister is to ensure the nation's energy security, to increase both the competitiveness of the economy and its energy efficiency, as well as to protect the environment. This objective will be achieved by means of diagnosing the current situation of the sector and proposing some directions for development. These matters are regulated in detail by Article 14 of ELA, which provides that state energy policy shall particularly specify the following: the fuel and energy balance of the country; the generating capacity of national sources of fuels and energy; transmission capacity, including cross-border connections; the energy efficiency of the economy; actions related to environmental protection; development of the use of renewable energy sources; the size and types of fuel reserves; direction of the restructuring processes and the property transformation of the fuel and energy sector; the fields of research and development, and international cooperation. This document is periodically updated. In accordance with Article 15 of the Energy Policy Act, the state's energy policy shall be prepared every four years. It should include an assessment of the implementation of state energy policy in the preceding period, a forecast covering a period not shorter than the next 20 years, and an executive programme for the next 4 years,

By Resolution no. 202/2009 of 10 November 2009, the Council of Ministers adopted the *Energy Policy of Poland until 2030*[34], replacing the previously applicable *Energy Policy of Poland until 2025*, adopted on January 4, 2005. Although energy policy should be updated every 4 years, so far the *Energy Policy of Poland until 2030* has not been updated even after 6 years. The minister's work on the new energy policy is in its initial phase. Drafts of the new energy policy, the forecasts, and the assessment of implementation of the the *Energy Policy of Poland until 2030* have been prepared, and in August 2015 were used in preliminary public consultation[35].

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[33] M. Swora, Z. Muras, *Prawo energetyczne*, Komentarz *[Energy Law Act: a commentary]*, Warsaw 2010, pp. 865 ff; A. Walaszek-Pyzioł, *Prawo energetyczne. Komentarz*, Warsaw 1999, commentary to Article 12.

[34] Resolution of the Council of Ministers no. 202/2009 of 10.11.2009 on the Energy Policy of Poland until 2030, RM-111-198-09.

[35] See the Public Information Bulletin of the Ministry of Economy, http://bip.mg.gov.pl/node/21394 (accessed: 17.07.2015) and the Public Information Bulletin of the Ministry of Energy, http://bip.me.gov.pl/node/24670 (accessed: 20.11.2016).

The place of LNG in "Energy Policy of Poland until 2030"

The *Energy Policy of Poland until 2030* only refers to the LNG market in a small part. LNG fuel is perceived as an element of external natural gas supply security. Hence, in accordance with item 3.1.1.2. of the Energy Policy, the main goal connected with natural gas is to ensure energy security by diversifying natural gas supply sources and directions. LNG is supposed to ensure such diversification. This will be achieved by opening the LNG terminal in Świnoujście, concluding contracts for LNG supplies "on market conditions", eliminating investment barriers to LNG infrastructure, and developing pilot programmes concerning the use of methane from coal deposits, which can also be converted into LNG.

Besides, the role of LNG technology in increasing the effectiveness of coal sector operations is also mentioned. Coal is to be the dominant fuel, guaranteeing Poland energy security. It is assumed that action will be taken to ensure the conversion of coal into gas fuels (including LNG) and the use of methane from coal deposits, which may also mean its conversion into LNG. Section 8 of *Energy Policy* also refers to the role of LNG in auxiliary activities. Those measures involve the activity of national public administration in international forums in order to develop energy policy with specific national considerations. The role of the Polish LNG terminal as infrastructure that enables diversification of natural gas supplies is explicitly mentioned.

The small economic importance attributed to LNG in the *Energy Policy of Poland until 2030* may be the effect of the historical character of the document. It was adopted in 2009 and was based on contemporary forecasts concerning the development of the LNG market. For the last 6 years, the market has changed considerably, which means that the document no longer fits actual conditions or anticipated directions of development. It does not include legal changes occurring since that time, either, e.g., the coming into force of the third liberalization package concerning energy markets or the activities of the European Commission aimed at ensuring competition in the EU energy sector[36].

The place of LNG in "Energy Policy of Poland until 2050"

The draft of *Energy Policy of Poland until 2050*, which is to replace the *Energy Policy of Poland until 2030*, takes into account the growing global importance of LNG. This is the effect of the increasing use of technology, particularly as a way of supplying gas from places without a gas pipeline infrastructure. The increasing potential of global natural gas extraction also

[36] K. Kloc-Evison, D. Koska, *Competition Law Mechanism as Additional Tool of the III Energy Package Implementation*, [in:] *EU Energy Law, Constraints with the Implementation...* op. cit.

makes LNG grow in importance. States and enterprises that invest in natural gas extraction, including extraction from unconventional sources, will try to sell the gas on global markets, leading to the formation of a global LNG market accompanied by the loss of significance of the gas infrastructure. Energy Policy estimates this direction of development as a significant new natural gas resource base, and hence a potential for the LNG market.

Diagnosing the current state of development of the gas sector in Poland, we can see an increase in infrastructure investments, including the completion of LNG terminal construction. Priority projects mentioned in the Energy Policy include the development of cross-border connections. Most essential in this context is increasing capacity at the borders with European Union member states and diversifying the gas supply routes to Poland. This underscores the importance of the LNG terminal in Świnoujście.

Discussing the direction of future changes in the energy sector, *Energy Policy of Poland until 2050* proposes three scenarios of development: (1) a balanced scenario, assuming the continuation of previous trends and the implementation of decisions taken with regard to the development of Poland's energy sector, as well as two auxiliary scenarios: (2) the nuclear scenario, forecasting a dominant role for nuclear energy in the energy balance of Poland, and (3) coexistence of natural gas and renewable energy sources, based on the assumption of beginning large-scale extraction of natural gas from unconventional sources, as well as development and popularization of technologies of energy generation from renewable energy sources. Natural gas is important in each of them.

The balanced scenario assumes retention of the significant (but less than now) role of coal and crude oil, and a moderate increase in the significance of natural gas. Domestic demand for natural gas may be met thanks to a stable supply, using complex gas infrastructure (LNG terminal in Świnoujście, Yamal-Europe gas pipeline, interconnectors). The share of natural gas in the primary energy balance is bound to increase, mostly at the expense of coal and – to a lesser extent – of crude oil[37].

In the nuclear scenario a 10–15% share of natural gas is assumed, with nuclear energy accounting for 45–60%. It forecasts reduced dependence on external supplies of natural gas and assumes greater competitiveness of the gas sector.

In the scenario of combined gas and renewable energy, the total share of gas in the energy mix is estimated to be 50–55%, including approx. 30–35% of natural gas. Natural gas is expected to foster the efficiency of renewable

[37] *Polityka energetyczna Polski do 2050 roku [Energy Policy of Poland until 2050]*, p. 35, http://bip.mg.gov.pl/files/PEP2050_v.0.2.pdf (accessed: 8.07.2015).

energy sources by stabilizing their volatility dependent on environmental conditions. This scenario also assumes a greater share of domestic gas in the energy mix of Poland – especially from unconventional sources. Gas is to serve as a fuel for chemical and petrochemical industries and for the production of electrical energy. Greater consumption of natural gas by individual consumers (enterprises for business purposes, and households for heating purposes) is also anticipated. Another point is the gradual increase in the use of natural gas in transport at the expense of liquid fuels.

Analyzing the proposed scenarios of natural gas and LNG's share in Poland's energy mix, we can see the rather secondary importance of gas in comparison with coal, nuclear energy, or renewables. The document assumes supplementing the fuel balance with natural gas, rather than treating it as a significant fuel in the economy. This assumption seems to be erroneous. Globalization of the natural gas market, resulting for example from the development of LNG, makes the utilization of this fuel more and more attractive due to its price and availability. Technological development makes use more and more flexible. It seems that solving short-term mining problems obscures the view of the long-term significance of the sector in energy industry[38]. The concept of nuclear energy development is also contrary to tendencies observed in the European Union, where the development of distributed generation, leading to self-reliance, is gaining importance. It seems that distributed generation operating as part of the model of virtual power plants, associated with an integrated wholesale energy market, is much more likely than the state's self-reliance based on large nuclear blocks. That is why it may occur that the national economic importance of natural gas, including LNG, will be higher than expected in the Energy Policy.

3.2.1. Regulations of the Energy Law Act concerning LNG

The functioning of LNG on the national market is based on the Energy Law Act of 10 April 1997, which specifies requirements concerning energy enterprises operating in the LNG sector, and framework regulations concerning installation security. ELA does not approach LNG separately, treating it as a gas fuel. Therefore, regulations directly referring to the operation of energy enterprises that trade in LNG, and the rules of such trade, are beyond the scope of analysis of this chapter. The analysis concentrates on peculiarities connected with LNG. Article 3 item 10b of ELA defines "LNG installation" as "a terminal used for: liquefaction of natural gas, or import,

[38] According to Robert Zajdler, treating coal as the key fuel in the economy is an assumption opposite to all trends occurring in developed countries.

unloading and re-gasification of liquefied natural gas, including the auxiliary installations and storage containers used in the process of regasification and supply of natural gas to the transmission system – with the exclusion of the part of the terminal used for storage purposes". The definition mentions two types of installation. The first is a terminal for liquefying[39] natural gas. The other type is installations used to convert liquefied natural gas, i.e. LNG, into gaseous fuel, so as to enter it into the network. The LNG system operator is responsible for the activity of such an installation, defined in Article 3 item 27 of the ELA as an energy enterprise dealing with liquefaction of natural gas: the import, unloading, or re-gasification of liquefied natural gas, and responsible for the use and maintenance of the natural gas installations. The terminology used by the legislator is somewhat puzzling. The term reserved for one of the processes carried out by LNG terminals – liquefaction – is used to define each type of LNG installation, although installations may be either re-gasification (like the terminal in Świnoujście) or liquefaction ones, or even combining both processes within the same technical infrastructure. It is obvious that translation of the English expression *Liquefied Natural Gas* highlights the element of liquefaction, but the legislator seems to use the acronym LNG with a different meaning. The Polish legislator's approach may be misleading, suggesting the special importance of liquefaction in relation to other processes occurring in LNG installations. Therefore, it is legitimate to introduce another term into the glossary of ELA, i.e. the term LNG, and separate its meaning from liquefaction and liquefied natural gas installations, which is indeed only one of the designates of the notion of LNG.

In accordance with Article 32 item 1 of ELA, a licence shall be required to perform business activity connected with the liquefaction of natural gas and re-gasification of liquefied natural gas at LNG installations. Unlike in the case of other concessions, there are no exceptions from the obligation based on the scale of activity. Thus, the national regulator assumed that full regulatory control is needed over the activity in this regard, and companies are required to implement a higher level of care, the level required of licensed energy enterprises. The regulatory approach as part of storage activity in LNG installations is also interesting. One cannot disagree that[40] "if an energy enterprise uses part of the natural gas liquefaction installation

[39] In the process of liquefaction, gas is purified from substances such as acidic compounds, mercury, heavy hydrocarbons, or nitrogen. After purification, natural gas is cooled to -161.6°C, which reduces its volume 600 times and changes it into liquid. As a result, LNG is very pure, made up of 95% of methane and only 5% of other components.

[40] A. Falecki, *Komentarz do art. 4e [Commentary to Article 4e]*, [in:] *Prawo Energetyczne Komentarz*, ed. M. Swora, Z. Muras, Warsaw 2010.

only for the purposes of storing liquefied natural gas, the enterprise will be obliged to obtain a license for economic activity in the area of storing gaseous fuels, and obtain a license from the President of Energy Regulatory Office including the appointment of an operator of the storage system for that gas liquefaction installation".

The legislator also points out the importance of regulations of *third party access* (TPA) with regard to LNG infrastructure. Article 4e section 1 of ELA reads that the installation operator shall be obliged to ensure equal natural gas liquefaction or liquefied gas re-gasification services to the customers and enterprises who sell gaseous fuels, "provided it is necessary for technical or economic reasons". Article 4i of ELA provides for an exemption corresponding to Article 36 of Directive 2009/73[41] analyzed before.

As for the application of the unbundling principle, the operator of an LNG system is not required to legally or organizationally unbundle. It only has to be treated separately in terms of accounting. Thus, the entity may remain part of the structure of an enterprise with vertical organization, without a separate legal personality or organizational structure. In practice, however, such entities operate within legally and organizationally separated structures because they aim to concentrate business risks connected with their activity within a single organizational structure. This situation is different than in the case of other entries to the national gas system, such as interconnectors, which operate within DSO or TSO structures. Entities discharged pursuant to Article 4i of ELA of Article 36 of Directive 2009/73 are an exception.

In order to deal with LNG, it is also necessary to approve a tariff in accordance with Articles 45-47 of ELA and the provisions of the Tariff Regulation (especially §29)[42]. Pursuant to Article 49 of ELA, the Chairman of the Energy Regulatory Office (ERO) may exempt an energy enterprise from the obligation to submit tariffs for approval upon finding that the enterprise is operating in the conditions of competition[43]. In its Information of 13th June 2013, the Chairman of ERO found that market conditions made it possible to exempt energy operators who had licenses for trade in gaseous fuels or trade in gas abroad from the obligation to submit LNG tariffs for approval. The process of establishing tariffs in Poland was found not to non-conform to European Union law (see case C16/14 European Commission vs Poland),

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[41] M. Swora, *Komentarz do art. 4i [Commentary to Article 4i]*, [in:] "Prawo Energetyczne Komentarz..." op. cit.

[42] Regulation of the Minister of Economy of 28 June 2013 on detailed terms for determination and calculation of tariffs and billing in trade in gaseous fuels (Journal of Laws of 2013, item 820).

[43] See M. Nowacki, *Legal aspects of Tariffs under the Third Energy Package: A Case of the Polish Gas Sector* [in:] "EU Energy Law, Constraints with the Implementation..." op. cit.

so we can expect the ultimate cancellation of mandatory approval of LNG tariffs, and that tariffs will be reduced to price lists prepared and applied by energy operators dealing with LNG.

Such services are provided on the basis of a contract which must include the provisions specified in Article 5 section 2 item 4 of the Energy Law Act. In accordance with this regulation, a contract should include provisions concerning: contractual effectiveness and the terms for amending it, the amount of gaseous fuels, the fee rate or tariff group used in settlements and the terms for introducing changes to that fee rate, the billing method, the responsibility of the parties for breach of the terms of agreement, and the terms of the agreement and of its termination. From the civil law perspective, such a contract is considered to be subject to other laws within the meaning of Article 750 of the Civil Code, to which regulations concerning purchase orders shall apply in issues not regulated in the contract. Concerning all other issues, the mutual rights and obligations of the parties result from the agreements between them.

Wholesale trade in natural gas is Poland is based on *over-the-counter* contracts and the exchange market. The latter has been especially strengthened by legal regulations in Poland[44]. Pursuant to Article 49b of ELA, operators are obliged to sell at least 55% of the high-methane natural gas pumped into the transmission network in a given year at the points of entry to the national transmission system, at connections with transmission systems of other countries, the network of mining gas pipelines, or at LNG terminals through a commodities exchange or another controlled market[45]. This obligation, however, only refers to the elements of trade that in the respective calendar year had the right to capacity at the entrance points to the national transmission system at connections with transmission systems of other countries (Article 49b section 1 of ELA) equal to at least 10% of the total capacity of all the entrance points to the transmission system (including the LNG terminal). This means that the capacity of the LNG terminal is not included in the capacity that may result in the obligation of trading on the controlled market. It is a kind of support for this point of entry to the national

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[44] See R. Zajdler, *Uwagi krytyczne do regulacji «obliga giełdowego» jako sposobu budowania hurtowego rynku gazu ziemnego w Polsce [Critical comments to the regulation of 'controlled market obligation' as the way of establishing the wholesale market of natural gas in Poland]*, "Humanities and Social Sciences", 21/3 (2014), Oficyna Wydawnicza Politechniki Rzeszowskiej, pp. 247-264.

[45] Pursuant to the Act of 26 October 2000 on Commodity Exchanges (Journal of Laws of 2014 item 197 consolidated text as amended) in the case of exchange, and pursuant to the Act of 29 July 2005 on trading in financial instruments (Journal of Laws of 2014 item 94 consolidated text as amended) in the case of other controlled markets.

gas system. From legal and technical points of view, there is no reason to treat this point of entry to the system as different than others. Such a regulatory approach may raise doubts concerning the rules for providing public assistance in the European Union, since it favors the institution. Entities that use the services of the LNG terminal have lower encumbrances than do entities which pursue the same goals at other points of entry to the national gas system. This regulation may result from the wish to develop this particular investment. However, in the long run we should expect repeal of the regulation that imposes controlled market obligation or eliminates the exemption[46].

3.2.2. Regulations concerning supply security and diversification

Pursuant to Article 24 of the Act of 16 February 2007 *on stocks of crude oil, petroleum products and natural gas, the principles of proceeding in circumstances of a threat to the fuel security of the State and disruption on the petroleum market* (Journal of Laws of 2014, no. 1695 consolidated text as amended), energy enterprises that carry out business activity involving trade in natural gas with other countries, and entities that import natural gas, shall be obliged to keep mandatory stocks of natural gas equivalent to at least 30 average daily imported amounts. The goal of keeping such stocks is to have a fuel reserve to be used in case of a threat to the state's fuel security, an emergency in the gas network, or an unexpected increase in natural gas consumption[47]. The provisions of the above-mentioned act do not introduce any exemptions concerning natural gas supplied through the LNG terminal.

Theoretically, they allow the keeping of stocks outside the territory of Poland if storage facility installations and transmission or distribution networks really make the gas available to Poland within 40 days and a contract has been made for the provision of storage services in a third party state that makes the gas available to Poland within 40 days. Disregarding the (currently theoretical) application of this provision, the act does not allow taking into account natural gas stored on tankers or other mobile LNG storage facilities in Poland or abroad. This is totally unreasonable. The availability of such gas for the purpose of ensuring security is comparable to its availability through onshore storage facility infrastructure or to gas supplied via a gas pipeline system. It seems necessary to transform the model of ensuring gas supply security from a technical approach to an obligation-based one. The obliged entity should ensure the availability of gas as part of its operation,

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[46] R. Zajdler, *Uwagi krytyczne do regulacji...* op. cit.

[47] M. Mordwa, *Gas Strategic Reserves Regulation in Poland and its Compliance with EU law*, [in:] "EU Energy Law, Constraints with the Implementation..." op. cit.

either by physical storage or by means of contracts, e.g., call options. The entity may choose the way of fulfilling the obligation. This will open new possibilities for LNG to play a role in this aspect as well.

Pursuant to Article 32 section 3 of the Energy Law Act of 10 April 1997, "upon a motion of the minister in charge of economic affairs, the Council of Ministers shall issue an ordinance which will specify the minimal level of diversification of gas supply from abroad by means of defining a maximal percentage share of the gas supplied by a single source. The ordinance shall specify the level of diversification for a period of at least 10 years." This provides the basis for the current Regulation of the Council of Ministers of 24 October 2000 *on the minimum level of diversification of gas supplies from abroad* (Journal of Laws 2000.95.1042). It sets the maximum proportion of gas imported from one country at 70% in the year 2014, 59% in the years 2015–2018, and 49% in the years 2019–2020. Delegated legislation being the basis for its issuance determines a specific maximum proportion of gas from a single source. The above regulation raises many legal doubts regarding an understanding of the source of natural gas in the context of developing a global market (including the LNG market)[48]. The possibility of purchasing gas from a number of countries through the LNG terminal provides diversification opportunities in itself. There is no need for this regulation to exist if the functioning LNG terminal safeguards the diversification of sources and directions of supply, and actual spot supplies of natural gas in a short time span. Hence, the LNG terminal offers certain flexibility even in critical situations.

3.2.3. Special regulations concerning the LNG terminal

Specific regulations concerning LNG were included in the Act of 24 April 2009 *on investments concerning the LNG re-gasification terminal in Świnoujście* (Journal of Laws of 2014, item 1501, consolidated text) The beginning of construction of the terminal in Świnoujście was based on the Resolution of the Council of Ministers in 2006 and deemed an investment of strategic importance for Poland; in October 2013, the European Commission granted it PCI status. Provisions of the act specify the rules of preparation, implementation, and financing of investment in the LNG terminal.

Another regulation aims to simplify and shorten administrative procedures connected with the preparation and implementation of the investment,

[48] R. Zajdler, M. Gałczyński, *Model systemu bezpieczeństwa dostaw gazu ziemnego w Unii Europejskiej. Postulaty de lege ferenda [The model of system of security of natural gas supply in the European Union: de lege ferenda demands]*, "Polityka i Społeczeństwo" no. 4(12)/2014.

including quicker issuance of permits required by the Water Law Act or decisions concerning changes in spatial development. The act also lays down a specific public procurement mode. If it is necessary for state security, purchase orders are performed in accordance with Article 4(5) of the Act of 29 January 2004 – Public Procurement Law (Journal of Laws 2004 No. 19 item 17). If the contract value is EUR 5,150 thousand or more for construction work and EUR 412 thousand for services or supplies, the contract shall be concluded on the conditions of fair competition, as part of an open, reliable, transparent, and non-discriminatory procedure. Contracts may be concluded for a period longer than 4 years, and Article 142(3) of the Public Procurement Law shall not apply. This facilitates the investment process. The Act shortens the time necessary for activities, makes deliveries considerably easier, introduces an obligation to concentrate documentation at the stage of submitting the application for a decision on investment location, and introduces procedural facilitations to apply if the real estate allocated for the investment has unclear legal status or if its land registration reference changes. The Act also provides for a number of additional investments to extend gas infrastructure, i.e. among others 3.5 thousand gas pipelines, mainly in the southern, eastern and south-eastern part of Poland and three connections with other countries (the Czech Republic, Slovakia, Lithuania), as well as gas storage facilities. The investment is an element of the EU North-South gas corridor, supplying gas to the neighboring countries.

A number of investments have been carried out in Poland under special purpose acts, which approach the rules of preparation and implementation of investments in a special way, usually because of inefficient general regulations or administrative processes. The aim of special purpose acts has been to facilitate administrative procedure, and their objective has been to quickly solve a complex matter on the basis of the *lex specialis derogat legi generali* principle. The best known acts are those on road investments[49], railroad transport[50], airports[51], LNG terminal[52] and nuclear power plants[53],

[49] Act of 10 April 2003 on special rules for preparing and implementing road investment projects, Journal of Laws of 2013, no. 0, item 687.

[50] Act of 28 March 2003 on railroad transport, Journal of Laws of 2007 no. 16, item 94 as amended.

[51] Act of 12 February 2009 on special rules for preparing and implementing investments in airports for public use, Journal of Laws of 2009 no. 42, item 340 as amended.

[52] Act of 24 April 2009 on investments concerning the LNG re-gasification terminal in Świnoujście, Journal of Laws of 2009 no. 84, item 700 as amended.

[53] Act of 29 June 2011 on the preparation and implementation of investments in nuclear power facilities and associated investments, Journal of Laws of 2011 no. 135, item 789 as amended.

as well as the Atomic Law Act[54] and an act on telecommunications[55]. Apart from these, some special purpose acts referred to incidental events, such as a flood or Euro 2012. The facilitations introduced by those acts result in taking new legislative initiatives concerning the regulation of new areas in a special way.

Incidental special purpose acts, applicable to limited time and scope of action, have mostly served as a means to simplify administrative procedures and quickly go through the administrative steps connected with the investment. The current number of special purpose acts and the intention to adopt others mean that the acceleration effect may only be illusory, especially in the case of investments already carried out under such acts by default, e.g. road construction investment. Nor is the act on transmission corridors (on which the government has been working for a few years) going to solve all the problems concerning the planning of public purpose investment.

Legal problems generated by special purpose acts, such as the lack of coherence of the legal system, collision between the acts, or unclear provisions, cause certain measurable losses for the business sector. The scale of extra costs connected with these problems is hard to estimate. It is a result of the length of the investment process, unclear solutions at its different stages, and the risk of interpreting laws contrary to the investor's interpretation. The special purpose act concerning the construction of the LNG terminal in Świnoujście has definitely simplified a number of general regulations, but it consolidated the tendency to solve the problems of certain investments with specific regulations instead of ensuring effective general regulation and administrative practice, which is detrimental from the systemic point of view. Experiences connected with the LNG act should be motivation to create effective general regulations.

3.3. Direction of changes in EU law concerning LNG

Building the wholesale market

Building an integrated natural gas market in the European Union requires the limitation or elimination of existing barriers, including those connected with the use of natural gas transport infrastructure. Such barriers include the existence of different national regulations referring to the functioning of national transmission systems. Historically, the rules of their functioning have been regulated at the national level. The rules for using interconnectors

[54] Atomic Law Act of 29 November 2000, Journal of Laws of 2012, item 264, as amended.

[55] Act of 7 May 2010 on supporting the development of telecommunications services and networks, Journal of Laws U. of 2010, no. 106, item 675, as amended.

were regulated by contracts between operators. Gradual integration of the natural gas market in Europe has made creating uniform regulations necessary for more effective functioning of intra-EU gas trade.

The response to this demand is market integration through so-called network codes developed by ENTSO-G on the basis of framework guidelines developed by ACER. The codes are currently at different stages of legislative procedure in the European Union. The principles of their establishment and change are specified in Articles 6–8 of Regulation 715/2009. The codes will refer to the following market areas: (1) network security and resilience, (2) connecting to the network, (3) third party access, (4) data exchange and billing, (5) interoperability, (6) operating procedures in emergency situations, (7) allocation of capacities and management of limitations, (8) commercial exchange regarding technical and exploitation organization of network access services and system balancing, (9) transparency principle, (10) principles of balancing, (11) principles concerning harmonized structures of transmission tariffs, and (12) principles of gas network energy efficiency.

Work on network codes has resulted in modifying the list of issues covered by these legal acts[56]. Currently, network codes refer to the key elements connected with the functioning of the wholesale market (intraday market, day-ahead market, derivatives market, balancing market), as well as the system of establishing tariffs or data exchange. Codes concerning capacity allocation, system balancing, transmission tariffs or interoperability and data exchange are significant from the point of view of LNG[57]. Regulation 984/2013 of 14.10.2013 establishing a Network Code on Capacity Allocation Mechanisms in Gas Transmission Systems and supplementing Regulation (EC) No 715/2009[58] aims to facilitate gas transport and gas trade in the European Union through ensuring more effective allocation of capacity at interconnectors, to provide support in the creation of a wholesale market, and to safeguard supply security and support the implementation and func-

[56] Commission Decision of 19 July 2012 on the establishment of the annual priority lists for the development of network codes and guidelines for 2013, OJ EU L 192 of 20.07.2012; Commission Decision of 21 August 2013 on the establishment of the annual priority lists for the development of network codes and guidelines for 2014, OJ EU L 224 of 22.8.2013; Draft of Commission Decision on the establishment of the annual priority lists for the development of network codes and guidelines for 2015, https://ec.europa.eu/energy/en/topics/markets-and-consumers/wholesale-market/gas-network-codes (accessed: 22.07.2015).

[57] R. Zajdler, *Rola giełdy energii w procesie budowania jednolitego unijnego Rynku Dnia Bieżącego i Rynku Dnia Następnego energii elektrycznej [The role of energy exchanges in the process of building a uniform EU energy intraday market and day-ahead market]*, "Humanities and Social Sciences" 21/4(2014), Rzeszów 2014, pp. 245–263.

[58] OJ EU L 273 of 15.10.2013, pp. 5–17.

tioning of the internal market in terms of gas trade and cross-border trade, including benefits for clients. Although the principles of allocation do not refer to LNG installation "exit points", uniform principles of allocation will improve the transparency of the market, important for LNG.

Commission Regulation (EU) No. 312/2014 of 26.03.2014, establishing a Network Code on Gas Balancing of Transmission Networks[59], introduces a common model of gas system balancing. As we can read in the Preamble, balancing is required of network users. Balancing itself should safeguard the development of the wholesale gas market for short-term transactions, by establishing trade platforms. In accordance with the regulation, the products will be allocated as part of an auction procedure organized on a capacity-trade platform selected by the operators. The platforms are to improve the efficiency of gas trade between network users and the transmission system operator. TSOs will ensure the needed supplementary balancing of transmission networks, taking into consideration the order of offers. When ordering gas, TSOs take into account both the economic and the operating aspects and use products that can be supplied from the broadest range of sources possible, including products from LNG installations. Transmission system operators should strive to satisfy their gas balancing needs mostly through the purchase and sale of standard short-term products on the wholesale gas market for short-term transactions. This is a new opportunity for LNG as a flexible source of natural gas purchase, although the rules of nomination established in the regulation do not now refer to LNG terminal entry points.

So far, the existing codes do not exhaust the scope of tasks listed in Article 8 of Regulation 715/2009. The implemented mechanisms undoubtedly help integrate national gas markets and build the internal market. However, there are still many challenges for users and national and communal institutions. Implementing the changes laid down in the network codes which are gradually coming into force requires many changes on the domestic gas market. Regulations included in network codes prove the process of building an internal market.

Technical integration of natural gas

Pursuant to Article 8 of Directive 2009/73, national regulatory bodies (member states) need to establish criteria for technical security, as well as develop and announce minimum requirements connected with technical design and exploitation of LNG installation connections[60]. The regulations are to ensure system interoperability, and are objective and non-discriminatory.

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[59] OJ EU L 91 of 27.03.2014, p. 15.

[60] M. Rudnicki, K. Sobieraj, *Nowe Prawo Energetyczne [New Energy Law Act]*, Wydawnictwo KUL, Lublin 2013, p. 104.

The solutions implemented at the international level (standards, codes of conduct, legal regulations) concerning LNG supply chain ensure the technical parameters of the installations. Specific legal regulations of the International Maritime Organization (IMO) are of special importance. The organization has adopted solutions concerning the security of LNG vessels construction and equipment, as well as navigation safety and environmental protection. IMO regulations also pertain to port infrastructure. EU legal solutions concerning the design of LNG infrastructure, navigation security, and environmental protection are also important. The European Committee for Standardization (CEN) has created more than 20 standards applicable in European Union member states, referring to different aspects of the functioning of the LNG supply chain[61]. These standards are the foundation for security and environmental protection of the installations. The LNG sector is also regulated by national laws, which supplement or implement international standards. Such comprehensive legal regulations guarantee a high level of security, both during the transport of LNG and at the terminals.

Changes in supply security

The regulatory model of the natural gas supply security system referred to in Regulation 994/2010 is likely to be modified. Analyses currently carried out by the European Commission show the direction of the changes. In the opinion of the European Commission, the provisions of Regulation 994/2010 leave too much room for individual definition of protected consumers. This allows different approaches in different member states, which may have a negative effect on the solidarity in individual regions and in the European Union. There are no instruments to meet the security standard required in the regulation. Member states appoint entities obliged to take up certain actions. The European Union has left with member states the implementation of regulations concerning supply security to protected consumers. Varied regulations in this respect, without presenting possible variants, has resulted in the existence of different unrelated, isolated systems. The N-1 parameter is only one of the parameters used to assess the resistance of the gas system to crises. It is based on maximum infrastructure capacities, disregarding factors such as the possibility of quickly starting supplies from alternative sources (e.g. LNG), or the level of diversification of natural gas, e.g. with LNG.

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[61] Example standards: PL-EN 1160:2008 *Installations And Equipment For Liquefied Natural Gas – General Characteristics Of Liquefied Natural*, PN-EN 1473:2007 — *Installation And Equipment For Liquefied Natural Gas – Design Of Onshore Installations*, PN-EN 14620:2010 — *Design and manufacture of site built, vertical, cylindrical, flat-bottomed steel tanks for the storage of refrigerated, liquefied gases with operating temperatures between 0°C and –165°C*, PN-EN 1252-1:2002 — *Cryogenic Vessels*.

It seems proper to point out a few elements that the new system should involve; for example, taking into consideration the developing LNG market. The system of safeguarding supplies should be based on all the gas enterprises that supply gas to consumers in the EU. The obligation level could equal e.g. 60 days of average consumption of a protected consumer. The point of reference for clearance of the obligation could be the obliged entity's volume of sale of natural gas to the consumer in the previous year (M-1), adjusted by the average value of change in domestic consumption in M/M-1 relation within the previous three years. This obligation would be fulfilled by means of one of two measures: (1) physical storage of gas in storage facilities or the "ticket" service, (2) having constant transmission capacity at interconnectors or the LNG terminal to be used in a critical situation, (3) having confirmed own resources of gas that can be used in a critical situation, with the proportion of storage and ticket services for meeting the demand of protected consumers not lower than 75%. In a critical situation, natural gas would be supplied to protected consumers without limitations, and to other consumers, through a commodity exchange. The point of reference would be the exchange price of gas. It would also be possible to administratively determine the maximum ratio of the price of stock provision and the market price, so as to prevent profiteering. The system would be based on greater collaboration and regional coordination. It would take into consideration the possibilities and significance of LNG as a flexible source of supply of natural gas, which could be quickly delivered to the national gas grid[62].

[62] R. Zajdler, M. Gałczyński, *Model wspólnego systemu bezpieczeństwa dostaw gazu ziemnego*... op. cit.

CHAPTER FOUR

The model of the global LNG supply chain

The development of the LNG market fits the contemporary energy policy of the European Union and is the subject of many regulations at the communal level. It is an important component of the natural gas market, a fuel whose proportion in the energy mix in the European Union at the moment exceeds 23%. Europe is now the world's greatest importer of natural gas, as it imports 42% of the total volume of fuel in international trade[1]. European countries were also the pioneers that established the LNG market, which had been evolving since 1959 until it accounted for more than 30% of global natural gas trade. Besides, the LNG market is complicated and dynamic. The elements of pricing liquefied natural gas at each link of the chain are determined by a number of factors, such as e.g. the technologies used, local and global macroeconomic determinants, and a balanced supply and demand. They affect the ultimate offer and its attractiveness for exporters and importers. Recently, the changes have been favorable for countries that import LNG, including the 10 EU member states. Poland is soon going to join them. If a country has LNG import infrastructure, it may participate in the only global natural gas market and can make use of the related potential. The current situation of the market is the effect of the globalization of the resource having gone on for several decades, but also of processes of change occurring in this decade.

4.1. Characteristics of the links of the LNG supply chain

The development of a global natural gas market has included development of the LNG market since the 1960s, with a considerable increase in volume especially in the latest 15 years. In 2014, the trade in liquefied natural gas was 33% of the global volume, i.e. 333 bcm.

Natural gas transport also requires the existence of defined processes in the whole supply chain. They can be grouped into four main categories:

[1] Except the Commonwealth of Independent States. Based on: *BP Statistical Review 2015*.

obtaining, liquefaction, transport, and re-gasification. In each group, there are cost categories affecting the ultimate competitiveness of the fuel from each source or the profitability of the investment project. Importantly, costs at each link do not only vary in terms of technologies used, but also depend on the specific place of acquisition, connected with the need to use local liquefaction infrastructure. They also depend on the importing country, where climate conditions may prevent the use of some re-gasification technologies. Moreover, costs change over time and are subject to economic laws of supply and demand, because both the LNG market and the sectors that support its functioning have recently been de-monopolized globally. Activities on global LNG markets require awareness of the relation between the links of the supply chain and their influence on the formation of the ultimate fuel price in international trade.

4.1.1. Obtaining natural gas

The first link of the LNG supply chain is obtaining natural gas, defined as a number of processes beginning with the production or obtaining of natural gas on the market up to entering it into the infrastructure of a liquefaction terminal. The costs of obtaining natural gas are determined by many factors, the most important of which are: the location of the source for obtaining natural gas (*onshore*[2] and *offshore*[3] sources)[4] and the distance between the source and the terminal, the construction costs of the production and transmission infrastructure, labor costs in the extracting country, and the scale of extraction. In literature there are many references to the share of costs of this supply chain link[5], ranging from 10 to 43% of the total price paid for LNG by the importer. These, however, are extreme values, and the share of each link of the chain in the total costs related to the purchase of natural gas depends on the costs of the other links, connected with variables such as the distance between the exporting and importing country, indexation formulas applied in contracts, or expenses connected with the technology used in liquefaction and re-gasification terminals. Some cost items also vary in time because of the volatile pricing of particular cost components.

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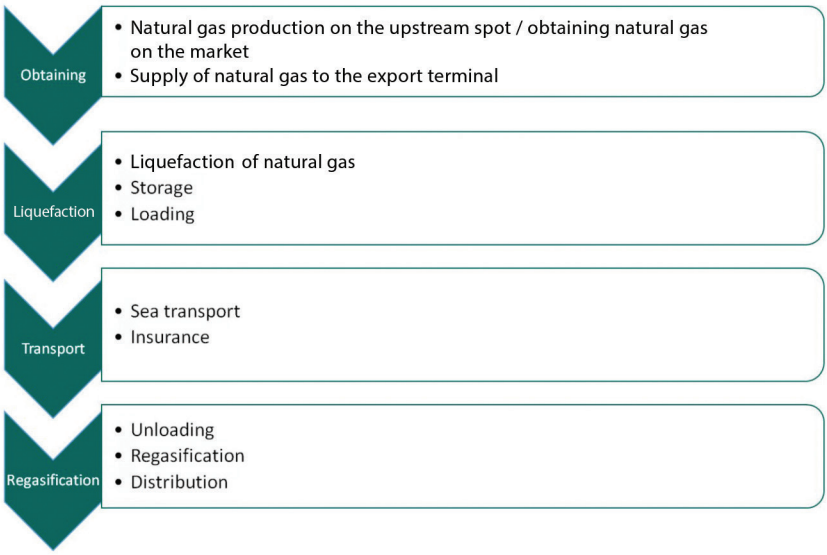
[2] The source is on shore.

[3] The source of natural gas is off shore.

[4] S. Rüster, A. Neumann, *Corporate Strategies along the LNG Value Added Chain - An Empirical Analysis of the Determinants of Vertical Integration, Globalization of Natural Gas Markets*, Working Paper WP-GG-17, 2006, pp. 1-13.

[5] S. Trzop, *Technologie budowy i eksploatacja terminali LNG [Construction technologies and utilization of LNG terminals]* part 2, 2011; *Current State & Outlook for the LNG Industry*, Rice Global E&C Forum, 2011.

Figure 1. LNG supply chain



Source: Own study

Most works point to the 20% share of cost of obtaining natural gas and transport to the terminal. In the analysis of expenses connected with Australia's plans to expand its export activity, expenditure of that link of the supply chain was divided for *offshore* and *onshore* projects. It is pointed out that the highest cost item concerning the construction of production infrastructure is the drilling of gas wells under the sea. The expense structure mostly includes expenditure connected with the hire of heavy machinery (50% of category costs). All in all, in an integrated project for constructing terminal and production infrastructure, the costs of drilling account for 15% of expenditure. Preparing the underwater infrastructure is not much cheaper, although the costs of renting equipment constitute a lower share (24%). The cost of installed equipment and construction materials is a bit lower. Other subcategories are construction of the platform and of the production, storage, and unloading facility[6].

Expenditure connected with drilling gas wells is, however, much higher in the case of onshore production installations, whose aim is to use deposits of natural gas from unconventional sources. This can be 32% of expenses

[6] M. Ellis, C. Heyning, O. Legrand, *Extending the LNG boom: Improving Australian LNG productivity and competitiveness*, 2013, pp. 36–37.

in an integrated project, even with consideration of material costs and the costs of installed infrastructure. Personnel costs are relatively high in comparison with offshore drilling. The research shows that onshore installation requires more investment expenditure, but the costs of projects vary substantially from country to country. They are especially high in Australia[7]. The cost of extracting a single unit of natural gas may be even 2 or 3 times higher there than in Qatar or North Africa. The country has recently carried out much investment to achieve an export leadership position on the global LNG market. However, as pointed out in the literature, the costs are high, which may be a barrier to development[8]. This is even more clearly visible when anticipated costs in Mozambique and Canada are compared[9].

Apart from the cost of production infrastructure, operating costs connected with extraction also play a role in determining the final price of natural gas. These are variables such as taxes, labor costs (including productivity), or optimizing processes[10]. All these amounts will have an impact on the cost of obtaining natural gas from upstream spots. The expected return on investment in this link of the supply chain is higher than in others (approx. 15–20%)[11], which is probably connected with pursuing a higher bonus related to having domestic natural gas production enterprises.

The US model for purchasing natural gas will be slightly different. Exporters largely buy natural gas at the Henry Hub in Louisiana. Currently, the price of natural gas at the Henry Hub is the most volatile natural gas price globally, much more than in the case of the most volatile European hub, the British National Balancing Point[12]. Purchase of natural gas at the American hub involves paying a transparent market price and supplying natural gas to the terminal's infrastructure. The Henry Hub price is publicly known, unlike e.g. prices of gas imported to Germany, only known afterwards. Since 2007, the price is also much lower than the rates of natural gas in other places of the world[13]. Because of a well-developed exchange market, exporters may even

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[7] Ibidem.

[8] D. Ledesma, J. Henderson, N. Palmer, *The Future of Australian LNG Exports: Will domestic challenges limit the development of future LNG export capacity?*, 2014.

[9] M. Ellis, C. Heyning, O. Legrand, *Extending the LNG boom: Improving Australian...* op. cit., pp. 36–37.

[10] *Australia's LNG sector comes under strain*, http://www.naturalgaseurope.com/australia-lng-sector-comes-under-strain (accessed: 26.07.2015).

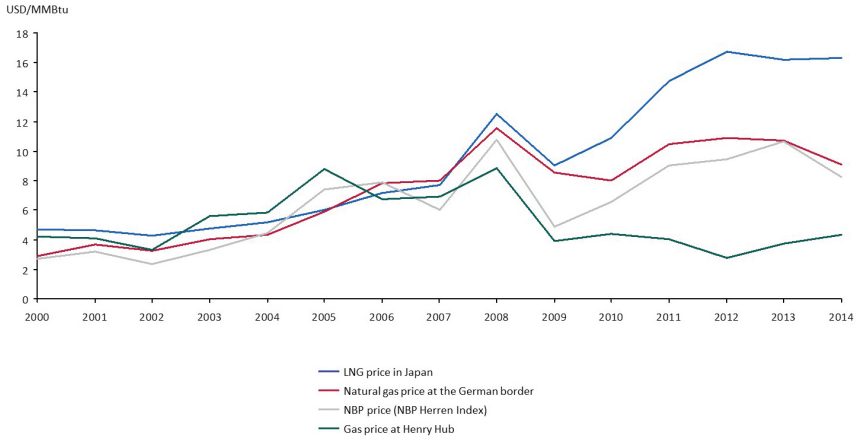
[11] *Current State & Outlook for the LNG Industry*, Rice Global E&C Forum, 2011, p. 26.

[12] *Gas Strategies Information Service, An Asian gas hub – a long revolution in the making*, October 2014, p. 5.

[13] The chart presents the mean annual price of natural gas. Since the second half of 2014, prices of natural gas on global markets have been decreasing.

secure the price of natural gas on international exchanges that have American gas in their product portfolios. Without domestic production of natural gas, exporters from the US will not have to incur investment expenses. If the terminals are located far away from the transmission grids, they will only need to cover the costs of constructing gas pipelines to the terminal.

Chart 7. Mean price of natural gas in USD/MMBtu[14] in the years 2000–2014



Source: *BP Statistical Review 2015*

Any construction costs of an installation for natural gas production, transmission infrastructure, or obtaining natural gas on the free market is ultimately covered by the consumer. However, the costs may influence the time of implementation of the expected return on investment. The price of natural gas all over the world decreased from the third quarter of 2014 to the middle of 2015. This had an impact on the scale of investment in the LNG sector, which is discussed more thoroughly in the chapter on trends in LNG markets. Yet, it is pointed out in literature that the costs related to search for and extraction of natural gas are decreasing as a result of using modern technologies such as 3-D seismic surveying, which makes it possible to more accurately locate natural gas deposits, technical improvements in submarine infrastructure, and drilling technologies[15].

[14] MMBtu – *British Thermal Unit*.

[15] M. M. Foss, *Introduction to LNG: An overview on liquefied natural gas (LNG), its properties, organization of the LNG industry and safety considerations*, Center for Energy Economics, Houston 2007, p. 25.

4.1.2. Liquefaction

Another stage in the LNG supply chain is liquefaction, broadly defined as the process of liquefying and purifying natural gas from unwanted chemical compounds, performed along with the processes of storage and loading gas on vessels. The costs of liquefaction are largely dependent on the technology used in the terminal. Currently, there are basically three methods of liquefaction: the classic cascade cycle, a cascade cycle with a mixed cooling factor, and a decompression cycle with the use of a turboexpander[16]. Each method may have several variants. Each also has certain effects on investment, including an influence on initial and operating costs. Relatively extensive installation is needed in the classic cascade cycle, but the process itself is not very energy-intensive. The cascade cycle with a mixed cooling factor, which is a modification of the cascade cycle, does not involve such complicated installations but is more energy-intensive. In the last technology, cooled natural gas is used to liquefy portions of natural gas. The technology itself is relatively low capital-intensive, but much energy is consumed during liquefaction[17]. The classic cascade cycle is currently used in the terminals of the world's biggest LNG exporter, Qatar, but also in Russia, the USA, and Australia. Energy consumption is relatively constant, about 270 kWh/ton of LNG. The cascade cycle with a mixed cooling factor is used in approx. 70% of the existing installations, e.g. in Algeria. Because of the applied technology, energy consumption varies from 275 kWh/ton of LNG up to 410 kWh/ton of LNG. The most energy-intensive technology is mostly used in small-scale installations and potentially on FLNG (*Floating Liquefied Natural Gas*) terminals. Energy consumption can reach 800 kWh/ton LNG[18]. According to exporters, the costs of liquefaction are the biggest cost category in the four groups of the supply chain. Extreme values vary between 28% and 45%, with the median at 38%[19],[20]. The main cost component is the liquefaction process, which accounts for 35–50% of costs of the whole link. The value of expenses connected with storage is approx. 25%, and energy and media consumption accounts for approx. 15% of costs. The

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[16] Portal Polskie LNG, http://www.polskielng.pl/lng/technologia-lng, [quoted in:] J. Molenda, Gaz ziemny. Paliwo i surowiec, 1996.

[17] Ibidem.

[18] Portal UNECE, http://www.unece.org/fileadmin/DAM/energy/se/pdfs/wpgas/session/1st_Session_Group_Experts_on_gas/2_-_Chapter_2_LNG_Study.pdf (accessed: 26.07.2015).

[19] P. A. Leroy, *History, trends and prospects for LNG shipping,* 2012.

[20] S. Trzop, *Technologie budowy i eksploatacja terminali LNG [Construction technologies and utilization of LNG terminals]* part 2, 2011.

total costs of liquefaction may vary by 20% from month to month and are dependent on operating and investment costs connected with the applied technology and on the possible economies of scale. The return on investment is estimated at 8% to 20%[21],[22].

Due to the specificity of investing in export capacity, investments in production capacity are often combined with investments in liquefaction terminals in the same projects. This is also the case in the currently greatest export project: the Gorgon project in Australia, worth USD 54 bn[23]. Australian projects are currently very capital-intensive, and although costs vary greatly, they may be from USD 2.37 bn Mt/year[24] to USD 5.2 Mt/year[25]. It is much more than the assumed mean computed by other entities, amounting to approx. USD 1.15 bn[26]. Investment costs often grow during the construction of infrastructure, which results among other reasons from labor costs or construction materials.

The choice of liquefaction technology is important for unit costs of natural gas, but is not a product functioning independent of other products. In the case of purchasing liquefied natural gas from a certain country, terminal costs are part of the price. At the moment, no liquefaction terminals are competing for the sale of natural gas from the same source, but the participation of American terminals in the international market may change the status quo. On the other hand, the costs of purchasing natural gas and contractual conditions may be so attractive from the importer's point of view that costs connected with liquefaction are not a negative stimulus in the choice of offerer. Furthermore, many commercial relations of our time date back to a time when there was no considerable excess of supply, allowing the free choice of the client, although despite many investment projects connected with export capacity, currently there is no great disproportion between export potential and demand[27]. In recent years, the growth of supply has been accompanied by growth of demand. While in 2004 total export capacity exceeded the volume of import by 34%, at the end of 2014 there was a 22% surplus over global demand. However, opening terminals in Australia and the United States and improving export capacity in some terminals (e.g. in

[21] *Current State & Outlook for the LNG Industry*, Rice Global E&C Forum, 2011.

[22] 8–12% if the fees are set by the state.

[23] As of July 2015.

[24] Mt/year – one metric tonne/year corresponds to approx. 1.36 bcm/year.

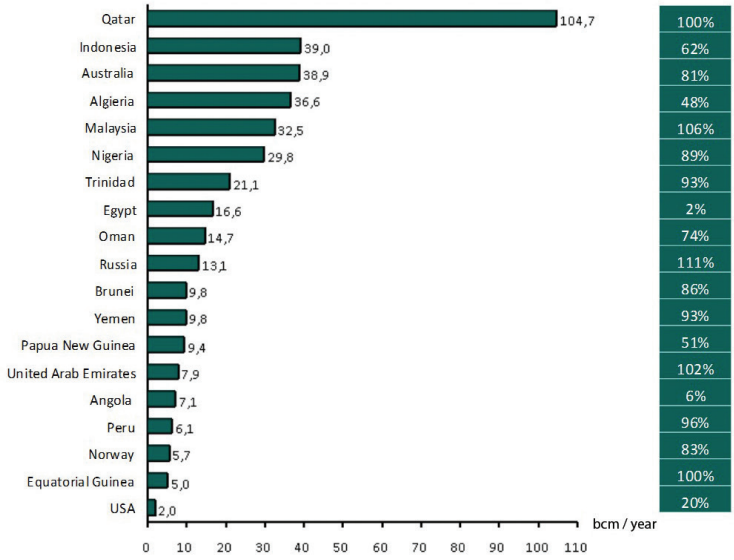
[25] Erroneous currency unit in the source text (USD million is used instead of USD bn).

[26] *Current State & Outlook for the LNG Industry*, Rice Global E&C Forum, 2011.

[27] Conclusion drawn on the basis of:*The LNG Industry*, International Group of Liquefied Natural Gas Importers, 2015.

Algeria) is going to lead to significant improvement of export potential and to competition between offerers.

Figure 2. Export capacity and the level of terminal utilization in LNG-exporting countries



Source: International Gas Union (IGU)[28]

Liquefaction terminals are currently intensively utilized, with the utilization level in many of them exceeding 100% (overproduction). In countries where the use of terminals is low, the reason may be the failure of export infrastructure (e.g. in Angola)[29], lack of energy resource (in Egypt)[30], or the opening of a new terminal (in Papua New Guinea)[31].

4.1.3. Transport

Liquefied gas goes to tankers, which are vessels designed to transport LNG, and in this way is transported to re-gasification stations in the port of destina-

[28] *World LNG Report – 2015 edition*, International Gas Union, 2015.

[29] *Angola LNG shuts down until 2015 for major re-build*, http://www.gastechnews.com/lng/angola-lng-shuts-down-until-2015-for-major-re-build (accessed: 26.07.2015).

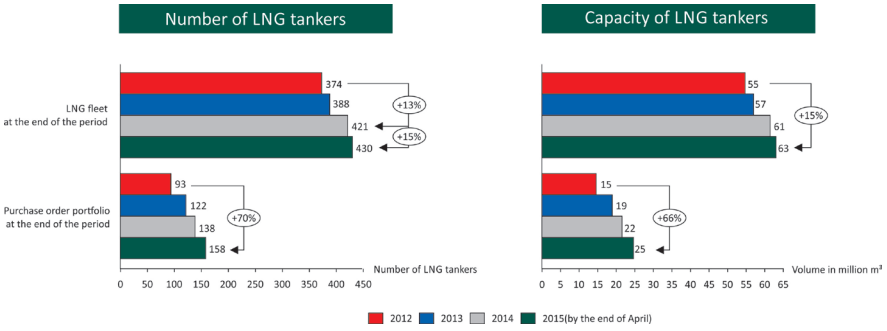
[30] *Gaz ziemny w Egipcie i nieoczekiwany zwrot sytuacji [Natural gas in Egypt and the unexpected turn of events]*, LNG Snapshot, 2015.

[31] *Papua New Guinea Begins LNG Exports*, http://thediplomat.com/2014/05/papua-new-guinea-begins-lng-exports (accessed: 26.07.2015).

tion. Costs in this link of the supply chain fluctuate due to high dependence on the market situation. Basically, the two main components of importers' expenses are transportation and insurance, but analyzing the subject more thoroughly, we can see certain determinants such as the size of the tanker, the length of the journey, the cost of fuel, or the cost of loss of natural gas during transport. Still another part of cost is expenses connected with the crew and maintenance of the vessels, plus the cost of insurance. As pointed out by market experts, the share of transportation costs in the price of LNG for the consumer varies from 10 to 30%[32],[33], with the median at approx. 22%, though it must be stressed that the oversupply of tankers resulting from large investment in recent years may soon contribute to lowering the costs of transport.

Between 2012 and April 2015, the number of tankers grew by 15%, and the order portfolio, by 70%. Similar values were found for the capacity of the vessels (a difference of 4 percentage points in the case of the order portfolio). Such increase in the active fleet and the order portfolio has led to a temporary fleet oversupply on the market, which has influenced transport prices. In the years 2012-2014, the pace of fleet growth exceeded the pace of growth of international LNG trade by 10 percentage points[34]. It can be concluded that the order portfolio which is going to increase global transport capacity by approx. 40% in the following years anticipates greater interest in the LNG market as a result of the emergence of new exporters, expanding the range of activity of those functioning now, and an increase in demand on the most dynamic markets, especially in Southeast Asia.

Figure 3. LNG tanker fleet and order portfolio in the years 2012–2015



Source: Calculated on the basis of *RS Platou Monthly*

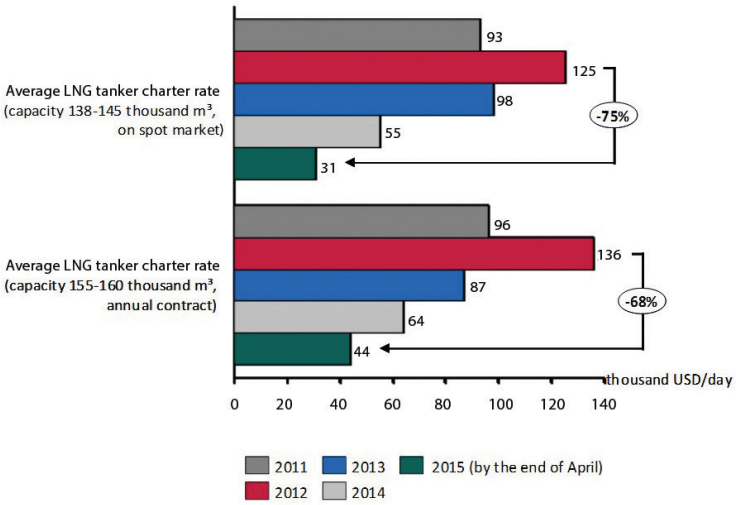
[32] P. A. Leroy, *History, trends and prospects for LNG shipping*, 2012.

[33] *S. Trzop, Technologie budowy i eksploatacja terminali LNG [Construction technologies and utilization of LNG terminals]* part 2, 2011.

[34] *RS Platou Monthly*, issues: December 2012, December 2013, December 2014, April 2015. Data on market growth come from *BP Statistical Review* 2015.

As a result of the increasing operating potential of the tanker fleet, accompanied by the relative stagnation of volumes in international trade, daily charter rates have significantly dropped. In 2015, tanker charter rates dropped by 75% in comparison with 2012. A similar decrease (by 68%) was observed in annual contracts. Such low rates are not likely to stay for long, although at present there are no market stimuli to promote growth. First, more vessels are going to enter the market, increasing the supply. Second, a warm winter all over the world reduced the demand for natural gas in many regions, contributing – apart from changes in oil prices – to lower prices of liquefied natural gas on short-term markets[35].

Figure 4. Average LNG tanker charter rates in the years 2011–2015[36]



Source: Calculated on the basis of *RS Platou Monthly*

However, the low prices of LNG transport are not everlasting and are going to change along with the changing market circumstances, which has already happened many times[37]. This aspect involves two main factors affecting the unit cost: the distance and the size of the contracted vessel. The size of the vessel allows achieving an economy of scale in the case of long dis-

[35] Information on prices is systematically published on the website of the Federal Energy Regulatory Commission (FERC) in the US.

[36] Data concerning tanker charter on the spot (short-term) market for the years 2011–2012 refers to the charter of a vessel with the capacity of 155 thousand m³.

[37] *RS Platou Monthly*, December 2014.

tances. Depending on the distance, transportation costs may have a greater or smaller share in the final fuel price. This relation is presented in Table 4.

Table 4. The share of transportation in the price of natural gas on short-term markets in January 2015[38]

Exporter/ Importer	Japan	China	India	Spain	Great Britain	Argentina	Brazil
Middle East	12.7%	11.4%	4.6%	14.6%	17.4%	16.4%	12.8%
Australia	8.5%	7.9%	9.7%	22.7%	26.2%	18.3%	14.7%
Trinidad	28.3%	27.2%	21.2%	9.0%	9.2%	9.7%	5.7%
Nigeria	20.3%	18.4%	14.5%	8.8%	9.8%	9.5%	5.5%
Algeria	21.1%	20.0%	14.1%	2.9%	5.2%	11.4%	7.6%
Peru	18.0%	20.5%	23.6%	20.9%	22.4%	8.6%	13.3%
Russia	4.5%	5.9%	13.6%	26.1%	28.6%	21.4%	18.0%
Spain	21.1%	20.0%	14.1%	N/A	5.2%	11.4%	7.6%
Norway	28.6%	26.9%	21.4%	10.1%	5.9%	17.8%	14.2%

Source: Original study based on information from FERC and Platts.

Considering Japan, the world's greatest importer of liquefied gas – in January the share of transportation costs in the price of LNG supplied from the Middle East was nearly 13%, while importing gas from Trinidad or Norway greatly increases the share of this link of the supply chain. In Europe, in turn, the share of transportation costs of natural gas from Africa is much lower than the cost of transportation e.g. from Qatar[39]. The relations are closely connected with the distance between source and destination ports. But again it must be stressed that the high costs that occur in one link of the supply chain may be compensated by much lower costs in other links.

4.1.4. Re-gasification

The last stage before the consumption of imported natural gas is its re-gasification and entry into the distribution system. The elements of this link are unloading, re-gasification, and entering the gaseous form of the resource into the distribution network[40].

[38] Price analysis based on data published by the American Federal Energy (FERC) with reference to the prices of transport of 8 January 2015 from an LNG Daily Platts report. Countries representative for given regions were chosen (Spain for Southern Europe, Great Britain for Northern Europe).

[39] R. Zajdler, *Najtańsze LNG dla Europy pochodzić będzie z Afryki [The cheapest LNG will be from Africa]*, http://www.cire.pl/item,100291,13,0,0,0,0,0,zajdler-najtansze-lng-dla-europy-bedzie-pochodzic-z-afryki.html (accessed: 28.07.2015).

[40] Some of the natural gas may be resold from the import terminal infrastructure of in the liquefied form. Currently, this way of sale accounts for a little percentage of natural gas transferred from re-gasification terminals.

Costs connected with activities in re-gasification terminals are the lowest out of all the links of the supply chain. They vary from 8% to 25%, but the median is about 15%[41],[42].

Re-gasification costs involve, on the one hand, the return on capital covering the investment expenditure, and on the other hand, operating costs. The rate of return of re-gasification terminals is estimated to be 8% to 10%[43]. Both operating costs and the amount of primary investment are affected by the applied re-gasification technology. There are several technologies for re-gasification of liquefied gas. These are SCV[44], applied in Świnoujście, but also STV[45], ORV[46] and AAV[47] technologies, as well as systems combining re-gasification with electricity production. Disregarding environmental matters, technologies of gas liquefaction differ not only in the construction costs of installation, but also the cost of consumed energy[48]. A relation is pointed out between those technologies in which low initial costs connected with the choice of technology trigger higher operating costs in the future[49]. The ORV system uses sea water as the only source of heat, which heats up liquefied gas in the installation and transforms it into a gaseous form. Unfortunately, due to different temperatures of water in global reservoirs, ORV cannot always be used to guarantee an effective re-gasification process[50]. SCV uses the heat of combustion of natural gas in order to heat up a water tank. STV is a similar technology, though in this case the heat exchanger is a closed circuit, and gas such as propane is used instead of water. AAV, just like ORV, uses the heat of sea water, with the support of an external source of energy, e.g. combustion of natural gas. The last technology allows the use of waste heat in electricity production in co-generation in the re-gasification process. The technologies used in the process of liquefaction are connected with the varying demand for energy, but as already mentioned, free choice has not always been possible due to the location of the terminal. Because of water temperature, terminals

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[41] P. A. Leroy, *History, trends and prospects for LNG shipping*, 2012.

[42] Ibidem.

[43] *Current State & Outlook for the LNG Industry*, Rice Global E&C Forum, 2011.

[44] Submerged Combustion Vaporizer.

[45] Shell and Tube Vaporizers.

[46] Open Rack Vaporizer.

[47] Ambient Air Vaporizer.

[48] B. Eisentrout, S. Wintercorn, B. Weber, *Study focuses on six regasification systems,* "LNG Journal", July 2006.

[49] Ibidem.

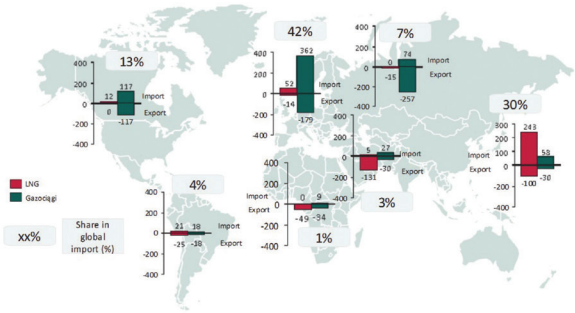
[50] M. Łaciak, *Techniczne i technologiczne problemy eksploatacji terminali rozładunkowych LNG [Technical and technological problems of utilization of LNG unloading terminals]*, "Wiertnictwo Nafta Gaz", vol. 28, part 3, 2011, pp. 507–519.

located in the Mediterranean Sea basin or in the regions of other warm seas are less dependent on external sources of energy, which translates into the ultimate cost of re-gasification. Another factor that needs to be taken into consideration is costs connected with the disposal of waste, which is an extra expense when using external sources of heat[51].

4.2. The EU's position in the global LNG market

The global LNG market is nowadays largely dominated by two regions. One is the Middle East with the greatest natural gas exporter, Qatar. The other is the countries of Asia-Pacific, especially Southeast Asia, where there are the biggest liquefied gas consumers. At the moment, European Union countries[52] are not the main consumers of liquefied gas in the global scale, and their share in export is marginal and only based on re-exporting imported natural gas[53]. But while the role of single member states in global export is small and the share in import is lower than that of the leading Asian countries, from the regional perspective, the EU countries including Turkey[54] are currently the world's second greatest consumer of liquefied gas.

Figure 5. International trade in natural gas in predefined regions in 2014



Source: Calculated on the basis of *BP Statistical Review 2015.*

European countries, except the Commonwealth of Independent States, are the group of countries that import the highest volume of natural gas in the world. On the one hand, this is the result of considerable dependence on

[51] B. Eisentrout, S. Wintercorn, B. Weber, *Study focuses...*, op. cit.

[52] As of July 2015.

[53] *The LNG Industry*, International Group of Liquefied Natural Gas Importers, 2015.

[54] The *BP Statistical Review* database presents data for Europe. Apart from terminals belonging to European Union member states, the only consumer is Turkey, responsible for 7.3 bcm. Thus, import by member states alone was 44.9 bcm.

external supplies (only the Netherlands and Denmark are net exporters), and on the other hand, the demand for energy resources connected with intensive energy development. It must be pointed out, however, that the best developed member states are less energy intensive than the developing ones[55], because the added value is largely produced in less energy-intensive sectors. European Union states are dependent on external sources of natural gas. In 2013, 12 out of 28 member states were 100% dependent on external natural gas supplies, and 5 others were 90% or more. Only 6 member states[56] were dependent on less than 80% external supplies. This includes the two countries that are net exporters[57]. In the case of seven countries, the high level of dependence is also connected with dependence on purchase from a single source in 80% or more with regard to the national supply of natural gas[58]. As a result, both European Union states and the European Union at the communal level aim at diversifying the sources of obtaining natural gas to ensure greater energy independence.

One source of natural gas diversification that enables the participation of this resource in the global market is investments in import terminals. Current members of the European Union were not only precursors of establishing that market in the past, but nowadays are also taking an active part in it, importing almost 45 bcm LNG, which is 13.5% of the global import of liquefied gas (73% goes to Asian markets)[59]. Import terminals are currently operating in Belgium, France, Greece, Spain, the Netherlands, Lithuania, Sweden, Portugal, Great Britain, and Italy. In 2015, an LNG terminal was also opened in Poland. On June 18, 2016, it was given the name of President of the Republic of Poland, Lech Kaczyński. Nowadays, the level of using terminal capacity in the European Union is low. This largely results from other possibilities for obtaining natural gas and from treating terminals as installations safeguarding supply security, not as a source of revenue that must be exploited in full. The low rate of terminal utilization is also connected with lower demand for natural gas by European consumers in 2014. On a year-to-year basis, it dropped by 11.2% y.o.y[60].

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[55] Energy intensity is defined as primary energy consumption per unit of gross domestic product.

[56] Net exporters: Denmark and the Netherlands, and importers: Poland, Great Britain, Croatia, and Romania.

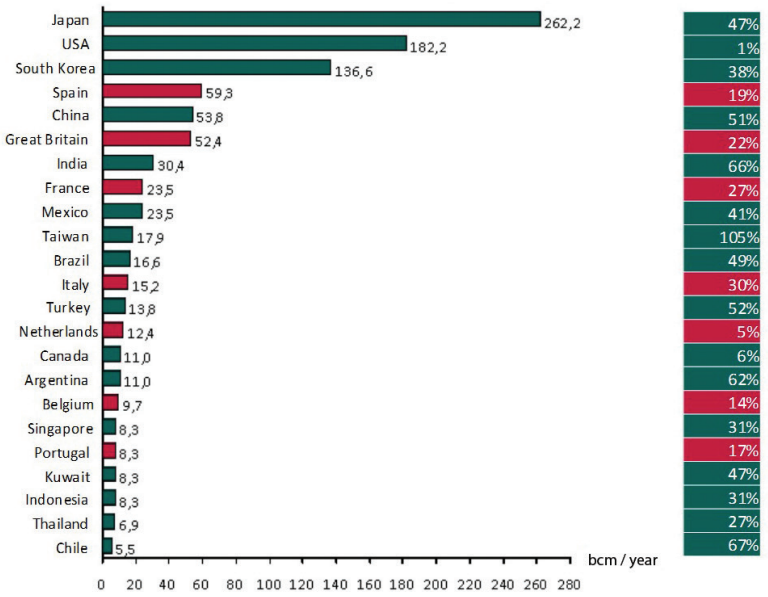
[57] *Statistical Report 2014*; Portal *Eurogas*, 2014.

[58] Calculated on the basis of Ibidem.

[59] *BP Statistical Review 2015*.

[60] *New Eurogas data confirms dynamic EU gas market*, http://www.eurogas.org/uploads/media/Eurogas_Press_Release__New_Eurogas_data_confirms_dynamic_EU_gas_market.pdf, (accessed: 27.07.2015).

Figure 6. Import capacity and the level of terminal utilization in LNG-importing countries



Source: International Gas Union (IGU)[61].

In the context of links in the supply chain, European Union countries – due to their position which is significant but not essential – are currently the recipients of changes occurring on those markets, without sufficient force to participate in forming the market. Currently, each country has its own gas policy, and attempts to unify the procurement policy[62] have not been successful[63]. Sill, each country may become a potential beneficiary of the changes occurring in each link of the supply chain.

First, great changes are currently occurring in natural gas production and investment in liquefaction terminals, which will have market effects in the foreseeable future. Large-scale investments in export capacity were carried out in Australia, where the Gorgon project is being completed as the greatest investment of the country so far[64] and – according to experts – the

[61] World LNG Report – 2015 edition, International Gas Union, 2015.
[62] Paying the price, http://www.economist.com/blogs/easternapproaches/2014/04/donald-tusks-energy-union, (accessed: 27.07.2015).
[63] A. Grzesak, *Unia energetyczna: jednak bez wspólnych zakupów gazu [Energy union without common gas procurement],* http://www.polityka.pl/tygodnikpolityka/rynek/1610497,1,unia-energetyczna-jednak-bez-wspolnych-zakupow-gazu.read (accessed: 27.07.2015).
[64] *Portal Chevron Australia*, https://www.chevronaustralia.com/our-businesses/gorgon (accessed: 27.07.2015).

second greatest investment in the energy sector[65]. But apart from the Gorgon project, other investments are under construction, which combined with the Gorgon project will improve Australia's export capacity by 90.5 bcm a year, Gorgon accounting for 21.4 bcm[66]. At the same time, processes are going on in the United States aimed at making the country a net exporter of natural gas; the first investments are going to be commissioned at the end of 2015[67]. Some investment is also planned in relation to discoveries of natural gas in West African countries, Mozambique and Tanzania, which in accordance with initial assumptions may begin the sale of natural gas at the end of this decade or at the beginning of the next one[68]. These and other investments are going to contribute to increasing the world supply of natural gas and to greater price pressure against offerers. The development of those investments could be blocked by the reductions in world oil prices that have occurred since the second half of 2014[69]. The lowest prices of crude oil, directly connected with the price of natural gas due to indexation formulas[70], cause longer periods of return on investment, and thus promote investment. What is important, while there are some projects that have been delayed or abandoned because of this phenomenon[71], investments which are in an advanced stage will probably be completed.

As a result of increase in supply, the exporting countries will try to obtain new consumers and will mainly address their offer to Asian countries, which are the hungriest markets for LNG. However, the increase in export capacity will probably not be accompanied by a corresponding increase in demand. Thus, consumers from the European Union may take advantage of market competitiveness and expect better offers and more flexibility of sellers.

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[65] The use of the Kashagan Field in the Caspian Sea is the most capital intensive. See J. Piszczatowska, *10 najdroższych inwestycji energetycznych świata [The 10 world's most expensive energy investments]*, wysokienapiecie.pl, 2014.

[66] M. Gałczyński, *Racjonalność inwestycji w zdolności przesyłowe w Australii [Rationality of investment in transmission capacity in Australia]*, LNG Snapshot, 2015.

[67] Cheniere Sabine Pass LNG U.S. export terminal to get first natgas soon, https://uk.finance.yahoo.com/news/cheniere-sabine-pass-lng-u-154501247.html (accessed: 27.07.2015).

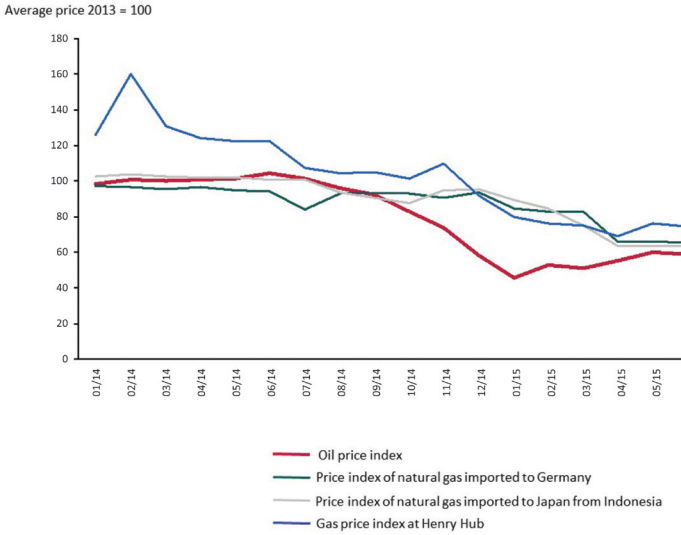
[68] R. Katakey, *Tanzania Sees Decision on $15 Billion LNG Project in Three Years*, http://www.bloomberg.com/news/articles/2015-06-19/tanzania-sees-decision-on-15-billion-lng-project-in-three-years (accessed: 27.07.2015).

[69] I. Marten, D. Jimenez, *Low Oil Prices Are Challenging Natural-Gas Markets*, https://www.bcgperspectives.com/content/articles/energy_environment_low_oil_prices_challenging_natural_gas_markets/ (accessed: 27.07.2015).

[70] Formulas in natural gas purchase contracts, which link the revaluation of purchase prices with the price of crude oil or oil derivatives such as light or heavy heating oil.

[71] I. Marten, D. Jimenez, *Low Oil Prices Are Challenging...* op. cit.

Figure 7. Global oil and natural gas price indices in the years 2014–2015[72]



Source: International Monetary Fund.

New technologies concerning the search for and extraction of natural gas are significant for consumers from the European Union. The biggest natural gas exporter from Africa and the second biggest exporter of LNG from the continent, Algeria, intends to invest USD 70 bn within the nearest 20 years in the extraction of shale gas[73]. Algeria is one of the closest LNG exporters for European Union countries, which are also the destination of 83% of gas supplies via gas pipelines and 84% of LNG supplies from the country[74]. The growth of export potential of the country is in the interest of the European Union, because the transport of natural gas from Algeria to terminals located in Europe, especially its southern part, is much cheaper than transport from more distant regions, which may translate into price for the resource.

Changes in costs of transportation and growing competition provide the possibility of obtaining natural gas under short-term and medium-term contracts[75]. In 2014, their share in total international trade reached 29% and is still growing[76]. Short-term contracts safeguard meeting the demand in the case of demand shocks and supply crises.

[72] Oil price is the mean price of oil on spot markets – Dated Brent, West Texas Intermediate, and Dubai Fateh.

[73] Portal *Arab News*, http://www.arabnews.com/economy/news/688131 (accessed: 27.07.2015).

[74] Calculated on the basis of *BP Statistical Review* 2015.

[75] Defined as purchase under contracts concluded for not more than four years.

[76] *The LNG Industry*, International Group of Liquefied Natural Gas Importers, 2015, p. 5.

In terms of liquefaction technologies, European Union countries use different solutions determined by the calculation of initial costs and operating costs, and often also by geographical latitude and climate zone. Recently, however, so-called FSRUs (*Floating Storage and Regasification Units*) are becoming more and more popular globally. Two such terminals in the European Union are now functioning in Italy, and one in Lithuania. Their advantage is relatively low construction costs and quick implementation. Their import capacity is limited by default, but for smaller countries or countries with diversified natural gas supply they are the best alternative to traditional on-shore re-gasification terminals[77].

4.3. Analysis of LNG potential in terms of Poland, regions, the EU, and global trends

The LNG market has been growing since its origin, to become an important component of the global natural gas market. International trade in liquefied gas, which originated in 1959 between the US and Great Britain, initiated European thinking about LNG as a potential but also real source of obtaining this fuel from new sources. Nowadays, liquefied gas goes to consumers from all continents, and because of its universal properties, it has become a commodity that can be used in the same way regardless of the place of purchase. Globalization has already contributed and is going to continue contributing to the creation of new sectors of the economy directly resulting from participation on the market, but also to the development of modern technologies and increasing energy security.

Analyzing the potential resulting from LNG in the context of significant elements of the supply chain, we need to take into consideration not only the potential connected with obtaining LNG but also with distribution, as liquefied natural gas can be re-gasified and entered into the grid or distributed in its liquid form. Moreover, even natural gas that is entered into the grid differs from natural gas purchased via pipelines. This is not the difference in physical composition (this difference is unimportant in the analysis) but in the source of obtaining it.

Sources of LNG are now located in 18 countries that export natural gas and in several countries that re-export it[78]. Ten years ago, there were only 12 such countries[79]. Today, no country in the European Union is connected by

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[77] *Terminale onshore i offshore – właściwy wybór państw bałtyckich [Onshore and offshore terminals – the right choice of the Baltic states],* LNG Snapshot, 2014.

[78] As of the end of 2014, based on *BP Statistical Review.*

[79] Ibidem.

a gas pipeline system with so many exporter countries. Creating an import infrastructure enables member states to participate in the global market without any limitations. The only criterion is the economic one, connected with the pricing conditions of LNG supply and contractual provisions that affect commercial relations. The previous paragraph describes investment projects connected with the emergence of the new export capacity on the market, mostly addressed to consumers from Asia. Yet Asia alone is not able to absorb all of the offered gas. What is more, the biggest consumer of liquefied natural gas, Japan, is going to return to producing electricity in nuclear power plants[80], which will reduce demand (or at least the pace of growth of demand) for LNG. Quickly growing economies, such as China, India, or Thailand, are not causing increased demand as fast as exporters expected. Russia's neighborhood with China and the pursuit of maintaining the key position on the natural gas market has caused a fight for the Chinese consumer, not only on the LNG market but also in terms of gas delivered via gas pipelines – a natural market substitute. Because of giving up on its nuclear programme, Iran is probably going to enter the market of energy resources, as it currently has the largest discovered deposits of natural gas. Countries investing in extraction capacity and liquefaction terminals will not have to compete fiercely for customers in Europe, but still Europe will be aware of the changes on global markets. In this context, the bargaining power of the European Union would of course be greater if Europe had a single stance, but a better offer can be expected anyway. Still, there is a risk. Due to the so-called Asian bonus, referring to a surplus of LNG prices on the thirstiest Asian market, the largest buyers from the region are strengthening their positions in relation to exporters, establishing group purchasing organizations[81]. As a result of increased competition, producers may look for compensation for lost benefits from smaller consumers, such as EU member states. Yet given the growing competitiveness of the market, this threat should not be treated as a real threat concerning all the offerers.

In European countries there is also a positive attitude toward absorbing more and more volumes of liquefied gas. On the one hand, the European Commission has taken action to remove from European gas contracts clauses securing the interests of main suppliers, such as a take-or-pay clause[82] or

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[80] P. Taberner, *Japan returns to nuclear to get economy back on track*, http://analysis.nuclearenergyinsider.com/operations-maintenance/japan-returns-nuclear-get-economy-back-track, (accessed: 27.07.2015).

[81] M. Iwata, *Japan, India to Form LNG Buyers' Group*, http://www.wsj.com/articles/SB10001424127887324094704579064670414569070 (accessed: 25.07.2015).

[82] A clause including obligation to receive a specific volume of fuel.

a destination clause[83], which has resulted in making the market flexible[84]. On the other hand, the tense political situation in Ukraine revived among EU politicians the need for activities aimed at diversifying natural gas supplies. Investments in LNG infrastructure, whether carried out in previous years or at the moment, not only enable the achievement of better prices of natural gas, but also improve energy security. This is especially important in countries largely dependent on natural gas supplies from Russia, in particular the countries of Central and Eastern Europe, including Poland[85]. Russia is and will remain one of the most important partners for Europe in terms of natural gas supply, but the existence of the positive impact of diversification, especially in Central and Eastern Europe, does not mean resigning from natural gas supplies from Russia, but rather aiming to achieve an equal negotiating position and lowering the level of diversification of prices of Russian gas in Europe[86], which had a negative impact on the countries of the region. The very functioning of the terminal is bound to improve the pricing flexibility of the Russian supplier, as pointed out e.g. by the example of change of bargaining power in contacts with Lithuania[87]. In this context, although LNG is the same energy resource as natural gas delivered through pipelines[88], it is another product with a positive impact on the consumer's situation.

On LNG markets there are also positive changes of prices in the sector of natural gas transport which, combined with the growing share of the spot market and medium-term market, enables those countries to purchase LNG to meet the growing demand in the country. Storage infrastructure makes it possible to cover temporary demand from natural gas stocks, but gas crises like the one in Ukraine in 2009 showed European countries how dependent they were upon a single source of supply[89]. That resulted in EU

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[83] A clause preventing trade in the energy resource in a country other than the buyer.

[84] *No more 'take-or-pay': Gazprom forced to end 40 year-old gas pricing regime*, http://www.rt.com/business/gazprom-rwe-germany-gas-893/ (accessed: 27.07.2015).

[85] Based on information on import dependence in 2013 from: *Statistical Report 2014*, Portal Eurogas, 2015.

[86] In the first half, the price of natural gas from Russia sold in Poland was 39% higher, and in the Czech Republic, 32% higher, than gas sold in Germany. See Russia beyond the headlines, http://rbth.co.uk/multimedia/infographics/2013/02/08/a_map_of_prices_of_gazprom_in_europe_22639.html (accessed: 27.07.2015).

[87] R. Milne, *Lithuania claims gas price victory in battle with Gazprom*, 2014, http://www.ft.com/intl/cms/s/0/2b6f3ef0-dab2-11e3-9a27-00144feabdc0.html#axzz3h7t3tMdu (accessed: 27.07.2015).

[88] For the purpose of analysis, differences in chemical composition are ignored.

[89] E.P. Sauvageot, *The Second Energy Crisis in Ukraine in 2009: Russo-Ukrainian Negotiations up to 2010 and the Role of the European Union, Analysis of a Challenge to the EU Diplomacy*, http://www.jhubc.it/ecpr-porto/virtualpaperroom/033.pdf (accessed: 27.07.2015).

regulations to improve the Union's gas security. Short-term market and low costs of transport provide European countries, especially within the region, with the opportunity to supplement storage capacities with natural gas from LNG supplies on short-term market. The time for a tanker to sail all the way from Algeria to the Świnoujście port is approx. 6 days, from Barcelona (one of the largest terminals in Europe from where Spain re-exports natural gas), 7 days, and from Zeebrugge in Belgium, only 1.5 days[90].

LNG also provides opportunities to distribute natural gas on a small scale, including the use of natural gas in road and maritime transport, the possibility of providing gas to regions or consumers not yet connected to the gas network, and the possibility of international trade in natural gas. For the construction of extra branches of application for LNG in a single country, region, or the whole European Union, a separate supply chain needs to be organized in which receiving terminals will function directly or indirectly.

Road transport using LNG as fuel already exists in the US and Canada, especially in cargo transport. LNG as a fuel is popular thanks to its physical properties, such as high energy value, economy, and environmental friendliness. The first ordered public transport vehicles are already being used in Olsztyn and Warsaw[91]. The development of LNG fuel in road transport currently faces at least two barriers. On the one hand, low prices of oil cause a lack of negative incentives, which leads to looking for alternatives. On the other hand, LNG not only competes with "traditional" fuels but also with another gaseous fuel: compressed natural gas (CNG). Still, within the region LNG-fueled vehicles are rare, and despite its advantages, no great changes are expected to happen soon. LNG propulsion is going to develop more dynamically in sea transport, as a result of environmental regulations in the Baltic and North Sea regions. Restrictive norms on sulfur oxide emissions in the SECA (*Sulphur Emission Control Area*) came into force on 1st January 2015 and have forced shipowners to change their fuel systems or discontinue operating in those reservoirs. The result has been a significantly increased order of LNG-fueled vessels[92]. However, it must be highlighted that LNG as a fuel does not meet high environmental standards, and shipowners much more often choose low-sulfur diesel oil[93]. The increase in demand for

[90] Based on calculator available on https://www.searates.com.

[91] *LNG w transporcie miejskim [LNG in city transport]*, LNG Snapshot, 2015.

[92] P. Nierada, *Bunkierka LNG szansą dla innowacji sektora gazu ziemnego w Polsce [LNG bunker ship as an opportunity for innovations in the natural gas sector in Poland]*, LNG Snapshot, 2015.

[93] *ESN – Way forward SECA report*, http://www.shortsea.info/openatrium-6.x-1.4/sites/default/files/esn-seca-report-2013_0.pdf, s. 17 (accessed: 27.07.2015).

LNG in both sea basins will provide a demand for natural gas and potentially create the need to develop universal ship bunkering technologies, both at ports and off-shore. Designing a dedicated supply chain has already been started by a company that imports LNG to the terminal in Lithuania[94], but the owner of the Polish terminal has also taken some action in this respect[95].

[94] *Statoil and Litgas Form LNG Bunkering Joint Venture*, http://worldmaritimenews.com/archives/165412/statoil-and-litgas-form-lng-bunkering-joint-venture/ (accessed: 27.07. 2015).

[95] P. Nierada, *Bunkierka LNG szansą dla innowacji sektora*... op. cit.

CHAPTER FIVE

Economic environment of the LNG market

As soon as the LNG terminal in Świnoujście is operable, Poland will become a more serious participant in the global LNG market[1]. The market will influence the economic situation in Poland, the region, and the European Union. The scale of this influence will depend on further market development. Still, it is worth analyzing the potential impact of the market on the economic environment. The current market of LNG suppliers is likely to change in the short-term perspective. New suppliers will appear, and technologies of extraction, liquefaction, transport and re-gasification will change. Therefore, this chapter also analyzes phenomena that may occur by 2020 and attempts to evaluate them.

5.1. Pricing of LNG

The prices of liquefied natural gas have varied greatly over the last 8 years. A similar fluctuation will probably occur in the ensuing years. To start, it is fitting to assess what activities have had an impact on historical fluctuations of LNG prices worldwide. In 2007, gas prices in the European Union, Asia-Pacific, the US and Canada were not very different. But four years later, the prices at exchanges in different regions began to vary.

The highest price was noted in Asia-Pacific countries; the lowest, in the US and Canada. If for purposes of comparison we adopt the rates applicable in Germany as a reference, in Japan in 2011 gas cost more than 40% more. The reasons for that may be different. Basically, the lack of supply-demand balance in some regions caused regional diversification of prices. This could have been intensified by the limited possibility of diversifying sources and directions of supply, especially in countries without an extensive gas pipeline infrastructure (Japan, South Korea) or temporarily dependent on LNG

[1] At the moment, LNG is supplied to Poland with the use of tank trucks. Poland also has small-scale LNG installations.

Table 5. The world – gas prices for the years: 2007–2014 (USD/MMBtu)[2]

Years	Japan	Germany	USA	Canada
2007	7.73	8.03	6.95	6.17
2008	12.55	11.56	8.85	7.99
2009	9.06	8.52	3.89	3.38
2010	10.91	8.01	4.39	3.69
2011	14.73	10.49	4.01	3.47
2012	16.75	10.93	2.76	2.27
2013	16.17	10.73	3.71	2.93
2014	16.33	9.11	4.35	3.87

Source: *BP Statistical Review of World Energy*, 2015, p. 27[3].

supplies. It can also be pointed out that the disaster at the Japanese Fukushima nuclear plant caused a spectacular price hike. As a result of the disaster, Japan shut down 48 of its nuclear reactors and made a transition to fossil fuels and LNG. Japan's demand for liquefied gas increased up to almost 121 bcm in 2014 and was nearly 2 bcm higher than the year before and over 30 bcm higher than in 2007[4]. This means a total growth rate (in the years 2007–2014) of 4.5%. However, the growth of demand for LNG in Japan was not the only factor that caused increased LNG prices in Asia. The other countries of the region, among them China, South Korea, India, and Taiwan, increased their demand for LNG. A total of more than 240 bcm LNG was purchased in 2014 in the region, i.e. almost 5 bcm more than a year before and more than 90 bcm more than in 2007. Thus, for the Asia-Pacific region the total rate of growth in the years 2007–2014 was 7.3%[5]. It is worth pointing out that forecasts made by the International Energy Agency in 2014 for the Asian market anticipate another medium-term growth in demand for LNG. High prices occurring in the region now and in the past (as compared to other regions) are going to decrease slightly within the next four years. According to forecasts, in 2014, LNG in Asia was more expensive by approx. 40% than in Europe, but in 2019 it will only cost ¼ more than in Europe[6], which

[2] MMBtu – one million British Thermal Units One Btu is the amount of energy necessary to raise or reduce the temperature of one pound of water by one degree Fahrenheit.

[3] *BP Statistical Review of World Energy, 2015*, p. 27, http://www.bp.com/content/dam/bp/pdf/Energy-economics/statistical-review-2015/bp-statistical-review-of-world-energy-2015-full-report.pdf (accessed: 7.07.2015).

[4] Calculated on the basis of: *BP Statistical Review of World Energy, 2012*, p. 28, http://www.bp.com/content/dam/bp/pdf/Statistical-Review-2012/statistical_review_of_world_energy_2012.pdf (accessed: 7.07.2015); *BP Statistical Review of World Energy 2008*, p. 30.

[5] Calculated on the basis of: *BP Statistical Review of World Energy, 2012*, p. 28, http://www.bp.com/content/dam/bp/pdf/Statistical-Review-2012/statistical_review_of_world_energy_2012.pdf (accessed: 7.07.2015); *BP Statistical Review of World Energy 2008*, p. 30.

[6] *Gas Medium – Term Market Report 2014*, IEA 2014, p. 33.

means that in four years the countries of the Asia-Pacific regional market will pay the highest prices for LNG. For these reasons, both new and present producers are focusing on that region.

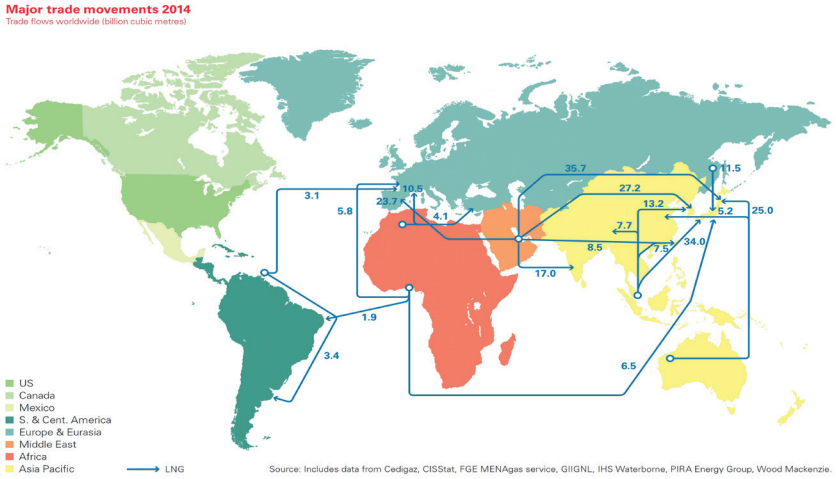
Table 6. Forecast gas prices in different regions of the world (USD/MBtu)

Years	Asia-Pacific (Japan)	Europe (continental)	Great Britain NBP	USA (Henry Hub)
2015	15.0	10.9	10.2	4.3
2017	14.3	10.4	10.2	4.3
2019	13.2	9.9	10.2	4.6

Source: *Gas Medium-Term Market Report 2014, IEA 2014,* p. 33.

The prices of gas are highest on Asia-Pacific markets. In North America, the situation is different. Whereas only eight years ago the natural gas price in the United States was about 76% of the German price, in 2011 it dropped significantly to reach only 39% of the price paid on the market of the biggest European economy[7]. Gas price drops in North America were caused by the beginning of unconventional gas production in the United States. As a result, in 2011, the price of the resource was almost 2.5 times lower on the American exchange than in Germany. This low-price tendency is going to persist not only in the United States but also in Canada. It is expected that within the next four years gas will be 50-60% cheaper there than in Europe.

Map 4: LNG trade in the world, 2014



Source: *BP Statistical Review of World Energy, 2015, p. 29*[8].

[7] Calculated on the basis of: *BP Statistical Review of World Energy, 2015*, op. cit., p. 27.

[8] Ibidem.

In relation to plans for beginning export of LNG from the United States, the question arises whether it may also be supplied to Poland and other EU member states, and whether the price of LNG from the US will be attractive. These questions are especially important given that the Transatlantic Trade and Investment Partnership (TTIP)[9] being negotiated at the moment also refers to energy resources. TTIP assumes the construction of a free trade zone between the USA and European Union member states, and one of the proposals discussed currently is unrestricted trade in energy resources. However, it is worth pointing out the priorities of the American energy strategy and particular investment decisions concerning the construction of liquefaction terminals in the US.

It seems that the main goal of the American administration is to maintain the low prices of natural gas on the domestic market. That policy is expected to enable, in the long run, inhibiting American investment in China or on other markets with cheap means of production, thus to restore the industrial economy in the US, and attract investors, for whom energy prices are of key importance in production costs. With such economic priorities in the United States, the export of natural gas must not shatter or make it difficult to maintain the policy of low energy prices on the internal market. That is why the volume of LNG allocated for export is to stabilize prices on the internal market, not to simply maximize profits from the export of energy resources. If too much American gas goes abroad, there will be a shortage on the internal market and prices will rise. If, however, too little natural gas is exported, the supply of gas will exceed demand, and prices may drop below the profitability threshold. To counteract these extreme scenarios, the US administration uses the instrument of limiting export permits. Administrative authorities granted the necessary permits for construction of LNG export terminals, giving consent to sales of the resource by countries that are not parties to the Free Trade Agreement with the United States[10] (for a total gas production volume of 94.4 bcm[11]). So far, decisions have not been taken to start building most of the LNG export terminals, and construction work may not begin in the near future. In 2015, analysts from the World Economic Forum noted that the great energy concerns were tending to suspend investment. This trend is connected with lower oil and gas prices and policies reducing cost and investment risk. These processes have contributed

[9] Transatlantic Trade and Investment Partnership (TTIP). A trade agreement between European Union countries and the United States aimed to establish a free trade zone. The negotiations began in 2013.

[10] Neither Poland nor the other European countries are bound with Free Trade Agreements with the US, https://ustr.gov/trade-agreements/free-trade-agreements (accessed: 7.07.2015).

[11] *Gas Medium – Term Market Report 2014*, op. cit., p. 157.

to lowering the export capacity of LNG from the US by approx. 70%. Only the Sabine Pass terminal will produce 24.5 bcm LNG, which is approx. ¼ of the planned capacity. In 2015, DOE agreed to increase the amount of liquefied gas for export to countries that have not signed the Free Trade Agreement with the US, which means that several dozen bcm more may be exported from the terminal in 2018[12]. Moreover, in April 2015, United States Secretary of Energy Ernest Moniz confirmed that the US intended to become one of the main exporters of liquefied gas and play a significant role on the LNG market[13]. This is very important for Poland and the other EU countries. It may be more difficult to buy the resource when production levels are not high and potential competition among consumers may be considerable. In addition, the American administration has prepared an innovative transaction formula, oriented at maximizing profits for American suppliers. Put simply, the new rules assume avoiding long-term contracts. The price of exported gas will depend on three parameters: the current cost of purchase of the resource on the internal market (the Henry Hub price), and liquefaction fees. The third parameter is connected with the price offered by the potential consumer. Gas will be sold to the one who offers the highest price. This way, the foundation for building a flexible market responding quickly to changes in demand has been created, instead of a model based on long-term supply, mandatory payment for gas that has not been received, and prices set on the basis of oil barrel price. The mechanisms applied by the US administration to LNG export clearly show that the gas will be purchased by those who offer the highest price. It is worth remembering that according to forecasts prepared by the International Energy Agency, in the next four years LNG prices in the Far East will be at least 1/4 higher than in European Union countries. What is not purchased in the far East may go to the European market[14]. The costs of LNG transport will also be important in that period. The global market, more and more based on spot supplies, will enforce effectiveness.

The price of LNG from the US offered on the EU market will be decisive. In the light of IEA data, gas may not be much cheaper: the difference may be around ten percent or slightly more. The IEA forecasts that whereas the cost of purchase of gas from the US remains at the level of USD 170 for 1 thousand m^3, the technical costs of supply of the resource to European consumers may

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[12] W. Krzyczkowski, *USA: jeszcze więcej LNG na eksport [The USA: even more exported LNG]*, http://wysokienapiecie.pl/statystyka/812-usa-jeszcze-wiecej-lng-na-eksport (accessed: 20.07.2015).

[13] *US to launch blitz of gas exports, eyes global energy dominance*, http://www.telegraph.co.uk/finance/newsbysector/energy/11563761/US-to-launch-blitz-of-gas-exports-eyes-global-energy-dominance.html (accessed: 21.07.2015).

[14] Calculated on the basis of: *World Energy Outlook 2013*, op. cit., p. 127.

vary: the lowest will not be much lower than the gas price; the highest, less than double the cost of purchase. Simplified calculations show that by 2018 the lowest price of gas from the US in the EU will reach USD 320 for 1 thousand m^3, and the highest, USD 430[15]. These calculations should be treated as an attempt to estimate the potential of the EU market in the context of global trends. But it may happen that new emerging sources of LNG extraction in the world will flatten prices due to greater competition from new suppliers and the existing ones wanting to retain the market. In 2014, the mean price of natural gas on the German market was approx. USD 353 for 1 thousand m^3 of gas[16]. Assuming that the current price on the German market does not go lower and the price of natural gas from the US remains in the aforementioned range, import from the US may not have great economic impact on the economy of the EU. Yet, there are also opposite views, indicating that new supply sources and greater diversification possibilities will contribute to greater price competition. Generally, however, the impact on prices should be positive[17].

Some analyses of the energy market have pointed to the indirect impact of export from the US on the global LNG market. The new formula of sales, based on the principle of supply to the best payer, which is indeed quite a common principle of sale, may lead to changing global pricing and contract rules, in particular to departure from the link between the price of natural gas and the price of crude oil and oil derivatives[18]. However, the pace of change will be proportionally dependent on the scale of American LNG export and the share of that export in the global volume of trade in LNG. As long as the scale of export is small and the US share in the global market is high, the pressure to introduce changes will not be strong. It seems, still, that the growing number of suppliers and the globalization of trade will increase market competitiveness and ensure the market appraisal of LNG[19].

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[15] Calculated on the basis of: *Medium-Term Gas Market Report 2013,* IEA 2013, p. 25, *World Energy Outlook 2013*, IEA 2013, p. 133.

[16] Calculated on the basis of: *BP Statistical Review of World Energy, 2015*, op. cit., p. 27.

[17] P. Turowski, *Bezpieczeństwo dostaw gazu dla Grupy Wyszehradzkiej i pozostałych państw Unii Europejskiej* [Security of gas supplies to the Visegrad Group and other EU countries], "Bezpieczeństwo Narodowe" quarterly, BBN, no. 30(2014), https://www.bbn.gov.pl/pl/wydarzenia/5731,quarterly-quotBezpieczenstwo-Narodowe-nr-30quot-25-lat-polskiej-strategii-bezpi.html (accessed: 21.07.2015).

[18] M. Gałczyński, *Globalny rynek LNG w 2014 r. rozwijał się mimo spadków w Europie [In 2014, Global LNG market was developing despite European drops]*, LNG Snapshot, May 2015; R. Zajdler, *Obniżka cen ropy naftowej wpływa coraz wyraźniej na spread w Japonii [The reduction in oil prices is more and more clearly affecting the spread in Japan]*, LNG Snapshot, June 2015.

[19] According to Paweł Turowski, perhaps newer, more flexible and more profitable rules of gas trade will become more popular after 2020, when an increase in export of liquefied gas from Northern America is anticipated.

Whether this happens or not, the import of LNG from the US to the European Union may contribute to a diversification of sources and directions of supply, thus strengthening the energy security of the EU.

5.2. Main LNG consumers

In this part of the analysis, the market of LNG suppliers will be presented from the historical perspective, from 2007 until now. The second part focuses on changes among producers that may occur in the medium-term perspective, i.e. until approx. 2019, and the third one presents forecasts concerning new producers after 2019. The market of LNG consumers can be divided into three regions: Asia-Pacific, Europe (actually, European Union countries and Turkey), and North America (Mexico and the declining US market). In 2007, 227 bcm LNG was purchased all over the world[20]. More than 147 bcm LNG, which is about 65% of the global production, went to Asia-Pacific countries[21]. The greatest amount, more than 88 bcm, was purchased in Japan, and nearly 35 bcm went to South Korea. Taiwan and India received similar amounts of LNG – approx. 10 bcm[22]. At the time, the demand for liquefied gas in China was only beginning: less than 4 bcm LNG was imported there[23]. The other market of consumers of liquefied natural gas was EU member states and Turkey. In 2007, over 47 bcm LNG, i.e. almost 21% of global LNG production, was sold to the EU. The greatest consumer in Europe was Spain, which received nearly 25 bcm LNG. The second greatest consumer was France with consumption of nearly 13 bcm. Italy, Portugal, Great Britain or Belgium were small consumers of LNG in 2007. Their purchase volumes were approximately 1.5–3 bcm LNG. In that year, Turkey received approx. 6 bcm LNG. The third market of LNG sales was two countries in North America, which in 2007 bought a total of approx. 23.5 bcm LNG – approx. 10% of the global LNG market. Nearly 22 bcm was received by the United States, and the rest by Mexico.

More or less in 2012, deep changes on the market became visible. Global sale of LNG increased by more than 30% and reached 327 bcm in comparison to 227 bcm in 2007[24]. That level of sales on the global market seems stable:

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[20] *BP Statistical Review of World Energy, 2008*, p. 30.

[21] Calculated on the basis of: *BP Statistical Review of World Energy*, 2008.

[22] Ibidem, p. 30.

[23] Ibidem, p. 30.

[24] Calculated on the basis of: *BP Statistical Review of World Energy, 2008*, p. 30; *BP Statistical Review of World Energy, 2013,* p. 29, http://www.bp.com/content/dam/bp/pdf/statistical-review/statistical_review_of_world_energy_2013.pdf (accessed: 9.07.2015).

in 2014, gas producers sold a total of 333.3 bcm LNG[25]. At the same time, significant differences in the scale of sale on particular markets occurred. The greatest amounts of gas were sold on the markets of Asia-Pacific. In 2012, almost as much LNG was sold as all over the world five years before (227 bcm). On North American markets, in turn, there was a rapid decrease in supplies. In 2012, the USA imported four times less LNG than in 2007 (nearly 5 bcm, compared to approx. 22 bcm of gas)[26], and in 2014, only 1.7 bcm LNG[27]. It is worth noting that market changes in the United States reveal a deeper process in which a previous importer of LNG may become a significant global exporter of LNG in the future.

The year 2012 was a vital year for the markets of EU countries. Then, the import level of LNG was relatively high for the last time, and reached more than 61.5 bcm (more than 23% higher than in 2007). Then, it dropped rapidly, and EU demand for LNG has been low since then. In 2013, EU countries only received 45 bcm, which was 14% of the world's production of liquefied gas, and in 2014, 44.8 bcm (13% of the global market)[28]. What caused this rapid decrease in LNG import to European Union countries? There are several reasons, but the crucial one is price. Gas coming through pipelines became cheaper than LNG and began to displace LNG from EU markets. While in 2007 the price of gas was comparable on exchanges in Japan, Germany and Great Britain, rapid growth of prices began in the Far East – the cost of LNG was 29% higher than on the German market[29]. In 2013, the price of LNG in Asia-Pacific was 1/3 higher than in Germany[30]. The difference in prices favorable for Asian markets produced re-export of LNG from Europe to Asia. Whereas in 2012 it was 4.5 bcm, one year later it leaped up to 5.7 bcm LNG[31]. This tendency is still present, as in 2014 LNG in Asia was sold at a price one and a half that in Germany[32].

The described phenomena occur in Western Europe and Greece, where there are the majority of LNG terminals in the EU. In the years 2013–2014, i.e. at the time of the lowest demand for LNG in EU countries, all the terminals used statistically 26% of their re-gasification capacities. At the time

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[25] *BP Statistical Review of World Energy, 2015*, op. cit., p. 29.

[26] Calculated on the basis of: *BP Statistical Review of World Energy, 2008,* p. 30; *BP Statistical Review of World Energy, 2013*, op. cit., p. 28.

[27] *BP Statistical Review of World Energy, 2015*, op. cit., p. 29.

[28] Calculated on the basis of: Ibidem.

[29] Ibidem, p. 29.

[30] Ibidem, p. 27.

[31] *Gas Medium – Term Market Report 2014*, op. cit., pp. 136–137.

[32] Calculated on the basis of: *BP Statistical Review of World Energy, 2015*, op. cit., p. 29.

of high import, in turn (60 bcm in 2012), the rate was 36%[33]. This means that even when the economic situation is profitable for LNG, more than 2/3 of re-gasification capacity remains idle, and when the situation is poor, almost 3/4 of terminals' capacity is not used. Despite the low efficiency of LNG terminals, more investments are being carried out, which considerably increase the possibility of import to European Union countries. Once they are completed, the capacity of the terminals will increase up to 204 bcm per year, from 184 bcm of re-gasification capacity in 2014[34]. If investments are properly designed, the profitability – including project financing – probably ensures the utilization of less than 1/3 of re-gasification capacity. New terminals are also being built because they facilitate the creation of a more flexible supply market, extend the group of suppliers with current and future LNG producers, and increase energy security of the country and region by diversifying directions and routes of supply.

It is worth emphasizing that for Central and Eastern European countries LNG terminals not only increase the security of long-term supply, but they may also generate competition on the supply market even in the short-term perspective. They ensure the diversification of supply through the creation of an alternative infrastructure, overcoming historical determinants. Whereas in long-term contracts LNG prices may prove more attractive than LNG (especially in the short-term perspective), spot purchase provides better opportunities for the LNG market. The change in the global approach toward purchasing natural gas from long-term to short-term purchases is an opportunity for LNG.

5.3. Previous and new LNG suppliers

In 2007, Qatar was the greatest LNG producer in the world, selling approximately 38 bcm. The second country was Malaysia, with production of almost 30 bcm, and the third, Indonesia, which sold more than 27.5 bcm. They were followed by: Algeria (approx. 24.5 bcm sold), Nigeria (over 21.6 bcm), and Trinidad and Tobago (more than 18 bcm of gas)[35]. Three countries were in the group selling more than 9–10 bcm LNG a year: Egypt (13.6 bcm), Oman (12.7 bcm), and Brunei Darussalam (9.3 bcm)[36]. Most producers concentrated on individual regional markets, and if they began selling to other markets, the amounts supplied there were considerably lower than

[33] Calculated on the basis of: *Gas Medium – Term Market Report 2014* op. cit., p. 206.

[34] Ibidem.

[35] Calculated on the basis of: *BP Statistical Review of World Energy, 2008*, op. cit., p. 30.

[36] Ibidem, p. 30.

to the key ones. Only Qatar diversified its consumers, selling approx. 2/3 of its production to Asia-Pacific and approx. 1/3 to the European Union. Countries such as Australia, Brunei, Indonesia, Malaysia, and Oman sold virtually all their production to Asia. At the time, most important for the emerging regionalization was the cost of freight, not price differences between markets. Although in the EU the price of LNG was about 10% higher than on the Japanese exchange, producers from Asia-Pacific countries concentrated on Asian consumers.

Table 7. Re-gasification terminals (existing and under construction), EU countries, 2015

Country	Existing re-gasification capacity (bcm/yr)	Under construction re-gasification capacity (bcm/yr)
Belgium	9	—
France	21.65	13
Greece	5	2
Spain	68.9	3
Netherlands	12	—
Lithuania	4	–
Poland	-	5
Portugal	7.9	—
Sweden	0.8	—
Great Britain	52.3	—
Italy	14.71	—
Total	196.26 bcm	23 bcm
Total (existing + under construction)	219.26 bcm	

Source: *GLE LNG Map: http://www.gie.eu/index.php/maps-data/lng-map* (accessed: 17.07.2015).

In 2007, LNG was supplied to European Union markets by producers from the Arabian Peninsula (Qatar) and Africa (Algeria, Egypt, Nigeria). Trinidad and Tobago sold small amounts of the resource from Central America. This market division, just like in Asia, was determined by the cost of freight. The main supplier to the third biggest market of North America (the United States and Mexico) was Trinidad and Tobago, which held more than a 50% share in the supply market, selling approx. 12.5 bcm LNG. The other part of the market was divided between three producers: Algeria, Egypt, and Nigeria[37].

[37] Ibidem, p. 30.

Table 8. Potential and previous suppliers of LNG to European Union countries

Country	2014	2019	2022
Africa, Arabian Peninsula			
Algeria	+	+	+
Egypt	—	possible	possible
Qatar	+	+	+
Nigeria	+	+	+
Mozambique	—	—	+
Tanzania	—	—	+
South and North America			
Trinidad and Tobago	+	+	+
Peru	—	+	+
USA	—	+(small amounts)	+
Canada			
Europe/Asia			
Russian Federation	—	+(small amounts)	+(small amounts)
Norway	+(small amounts)	+(small amounts)	+(small amounts)

Source: *Source: author's estimates and forecasts based on: Gas Medium-Term Market Report 2014, IEA 2014, op. cit.*

LNG production in Qatar grew within just five years by nearly 200% from approx. 38 bcm to more than 105 bcm LNG[38]. Less spectacular but also significant growth in production occurred e.g. in Nigeria. Russia joined the group of LNG producers, producing almost 15 bcm LNG in 2012[39]. It should be remembered that in 2007 the global LNG market was on the verge of rapid changes. Several important producers were building new liquefaction installations, and the demand for LNG was quickly growing in the Far East. Investment processes were accompanied by the additional element of beginning huge production of unconventional gas in the USA, which also initiated the process of deep changes on the LNG market.

Seven years later, in 2014, approximately 1/3 more LNG went to the market – over 333 bcm[40]. The greatest producers were still Qatar (over 103 bcm) and Malaysia (nearly 34 bcm). Australia became the third largest producer. Within seven years, its production grew by more than half and reached over 31 bcm (as compared to approx. 20 bcm in 2007). The Russian Federation joined the group of important LNG producers, supplying more than 14 bcm LNG in 2014[41]. IEA forecasts indicate that in the years 2014–2019 the global LNG market is going to face dynamic changes. So it is worth checking when

[38] Calculated on the basis of: *BP Statistical Review of World Energy, 2008*, op. cit., p. 30; *BP Statistical Review of World Energy, 2013*, op. cit., p. 29.

[39] *BP Statistical Review of World Energy, 2013*, op. cit., p. 28.

[40] Calculated on the basis of: *BP Statistical Review of World Energy, 2015*, op. cit., p. 29.

[41] Ibidem.

they will take place and whether it will be possible to buy LNG at a cheaper price or which country can be a new important supplier for EU markets. IEA points out that until 2019 there will be a significant increase in global sales of LNG, up to 450 bcm. This means an increase of almost 40% in comparison to the 322 bcm sold nowadays[42]. It must be stressed that gas trade is and will probably be lower than current and projected production capacities. In 2014, the capacities of liquefaction terminals all over the world reached 390 bcm. Within the nearest four years, production capacities are to increase by another 150 bcm[43]. In order to estimate how much the markets of European countries may provide for the new terminals, we need to see where they will be built.

Table 9. LNG production terminals under construction in 2014, globally. IEA estimations

Country	Project	Capability of LNG production (bcm/yr)	Commissioning (years)
Asia-Pacific			
Australia	Queensland Curtis	11.6	2014/15
Australia	LNG	20.4	2015/16
Australia	Gorgon LNG	10.6	2015/16
Australia	Gladstone LNG	12.2	2015/16
Australia	Australia Pacific	12.1	2016/17
Australia	LNG	4.9	2017
Australia	Wheatstone	11.4	2017/18
Indonesia	Prelude LNG	2.7	2014
Indonesia	Ichthys	2.7	2014
Malaysia	Sengkang	0.9	2014
Malaysia	Donggi-Senoro	4.9	2015
Malaysia	LNG	1.6	2016
Russia	MLNG LNG plant MLNG Train 9 Kanovit FLNG Yamal LNG	22.4	2018/20
Africa			
Algeria	GassiTouil LNG	6.4	2014
South and North America			
Colombia USA	Pacific Rubiales FLNG Sabine Pass LNG	0.7 24.5	2015 2016/17
Total		150 bcm	

Source: *Gas Medium-Term Market Report 2014, IEA 2014,* op. cit., p. 149.

[42] *Medium Term Gas – Market Report 2014*, op. cit., p. 145.

[43] Ibidem, p. 149.

It must be mentioned that estimates concerning the construction of LNG terminals differ a lot depending on the publishing center. For example, the above list of investments in LNG liquefaction terminals does not include the investment in Papua New Guinea opened in 2014. On the American market, we can see only one investment, Sabine Pass, implemented in 2014. On the other hand, Federal Energy Regulatory Commission presents the construction of five export terminals in 2015 (Sabine, Hackberry, Freeport, Cove Point, Corpus Christi[44]), but only three of them are also mentioned by the International Energy Agency. Due to methodological challenges described here, IEA data should be treated with caution and with the assumption that a significant prognostic mistake may occur.

Most of the new production capacities will be built in the Asia-Pacific region. Australia is the leader in the region, building new terminals with capacities exceeding 80 bcm a year[45]. The Russian Federation will be the other big producer in the region if it carries out the huge project on the Yamal Peninsula, with a production capacity of over 22 bcm a year[46]. Malaysia and Indonesia are the remaining producers. There are different opinions concerning the destinations of LNG from liquefaction terminals. The decisive factors will be the possible price, transportation costs, and the absorption capacity of the market. The length of contract should also be taken into consideration: the derivatives market is likely to differ from the spot market. The markets of Asia-Pacific may still remain an interesting destination of supplies as part of derivatives market.

So which of the new producers may supply gas to Europe until 2019? Although the list of new investments is dominated by producers from Asia-Pacific, it is hard to assume that they will supply European markets, both because of the great distance and the related cost of freight. Anticipated higher selling prices of the resource on Asia-Pacific markets also play a role. Regarding new producers, the Russian Federation is often mentioned as the supplier of LNG to the Central European market. Currently, Russia produces approx. 14.5 bcm LNG a year, but production is going to increase as the terminal on the Yamal Peninsula becomes operable, which is planned for the years 2018/2020. The new Russian terminal will produce more than 22 bcm gas a year. Apart from these investments, the IEA has announced plans for more investment, with a production capacity of over 47 bcm of gas a year. One will

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[44] *Approved North American LNG Import/Export Terminal*, Federal Energy Regulatory Commission, http://www.ferc.gov/industries/gas/indus-act/lng/lng-approved.pdf (accessed: 29.07.2015).

[45] Calculated on the basis of: *Gas Medium – Term Market Report 2014*, *IEA 2014,* op. cit., p. 149.

[46] Ibidem, p. 149.

be the project of a terminal located by the Baltic Sea. But the list should be treated with great caution. Some of them have not been very realistic from the beginning, and their announcement is part of a play of information by different entities of the Russian Federation rather than actual plans. In addition, the chances of implementing some of them are negatively affected by two crucial recent factors. The first is political: military attack against Ukraine directly stops foreign investment in the energy sector and accelerates the political actions of many countries in order to reduce dependence on Russian oil and gas supplies. The other factor is connected with the rapid drop in gas prices all over the world, causing the suspension or withholding of many extraction and investment projects. It is worth mentioning that Russian plans for intensive expansion of LNG terminals were created several years ago, when prices were very high and allowed quick return on the invested funds. The IEA estimated all the investment projects planned by Russia in the sector of natural gas to reach almost USD 1.1 trillion by 2035, whereas expenditure for the construction of liquefaction terminals will amount to USD 80 bn[47]. For comparison, investments in the crude oil sector were estimated at USD 790 billion[48]. Nowadays, such investments seem to be totally unrealistic, and the enormous financial expenditure illustrates the cost of construction of the only existing LNG terminal – Sakhalin 2 – with export capacity of 14.5 bcm gas per year. It was built in 2009 for the huge amount of USD 20 bn, and was financed by concerns from the Netherlands, Great Britain, and Japan, which are members of the consortium[49]. The price of gas was very high then, and foreign concerns were ready to invest a lot in return for consent to investing in Russia. However, this good economic situation ended, and the example of Russian-Chinese agreement for construction of the "Power of Siberia" gas pipeline illustrates well the difficulty of obtaining funds for single projects in the changing economic and political situation[50]. It is also worth pointing out the goals of the project for developing LNG export in Russia. The first was economic: the construction of sea terminals in the Far North in barely accessible locations due to critical atmospheric conditions was cheaper than building new gas pipelines. That technology

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[47] World Energy Outlook, International Energy Agency, 2011, p. 334.

[48] Ibidem, p. 334.

[49] Na Sachalinie pierwsza w Rosji fabryka skroplonego gazu (LNG) *[The first Russian LNG production plant on Sakhalin]* (corrected), PAP, 18 February 2009.

[50] See: E. Fischer, S. Kardaś, W. Rodkiewicz, *Rosnące koszty zbliżenia. Nowe rosyjsko-chińskie umowy gospodarcze [The growing costs of closer relationship: new Russian-Chinese contracts]*, OSW analysis of: 15 October 2014, http://www.osw.waw.pl/pl/publikacje/analizy/2014-10-15/rosnace-koszty-zblizenia-nowe-rosyjsko-chinskie-umowy-gospodarcze (accessed: 20.07.2015).

allowed local investment close to the places of extraction. The other goal was political: Russia has always treated the export of gas using LNG technology as an instrument of consumer diversification. If all the existing pipelines are focused on the West, strengthening the dependence on consumers from Europe and Asia Minor, liquefaction terminals (together with two gas pipeline projects) would provide a counterbalance to Asia-Pacific markets, e.g., Japan, South Korea, China, Taiwan, and India[51]. The Asian orientation was additionally strengthened by higher gas prices since 2011. These relations show that it is unlikely for the Russian Federation to shortly become a significant LNG supplier to European Union markets. Still it is possible that, in future, small amounts from the currently constructed terminal on the Yamal Peninsula will go to the West. Actually, Russia is developing the LNG sector with a view to Asia-Pacific markets. It supplies the resource to the West using gas pipelines, so Russian LNG in the European Union is justified on the Iberian Peninsula and in Great Britain, where there are no pipelines, or they only allow little export. Potentially, Russian LNG may be used to try to maintain dominance in Central Europe. Even the receiving infrastructure of an LNG terminal offers technological, legal, and business advantages, which the consumer can use to maintain supply security.

Although export from North America will begin at the moment of commission of the large terminal Sabine Pass, its importance on the global market will grow after the start of several more investments. Export growth largely depends on licenses from the Department of Energy to export liquefied gas to countries that have not concluded the Free Trade Agreement with the United States. In Asia, only Korea has signed the agreement; in Europe, no country has done so. Thus, without the license LNG could not be delivered to the two most important regional markets of the world. Until 2014, the Department of Energy had granted permits for the construction of terminals with a total expected export capacity of 95 bcm a year. It must be emphasized that even if the permits are not granted, after completion of terminals that have already been permitted, the United States will probably become the third LNG exporter in the world anyway. This may occur within five years[52]. The IEA forecasts that from the beginning of the third

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[51] More on the Russian strategy: *Energy Strategy of Russia for the Period Up To 2030*, Ministry of Energy of the Russian Federation, Moscow 2010, http://www.energystrategy.ru/projects/docs/ES-2030_%28Eng%29.pdf (accessed: 20.07.2015), and P. Turowski, *Eksport rosyjskiego gazu.– strategia, plany, konsekwencje [Russian gas export: strategy, plans, consequences]*, "Bezpieczeństwo Narodowe" quarterly, BBN, no. 23–24(2012), https://www.bbn.gov.pl/pl/prace-biura/publikacje/kwartalnik-bezpieczens/4343,Kwartalnik-Bezpieczenstwo-Narodowe-nr-23-24-Glowne-ustalenia-i-rekomendacje-SPBN.html (accessed: 20.07.2015).

[52] *Gas Medium – Term Market Report 2014*, IEA 2014, p. 156.

decade of the 21st century, after completion of all the currently prepared projects of sea LNG terminals, the US will become the world's third biggest exporter of liquefied gas, selling little less that the previous leader, Qatar (which currently produces approx. 105 bcm a year[53]). The expected change may be significant for Poland and other LNG consumers in Europe, because it increases the probability of supplying LNG from the US to satisfy national and regional demand. Even considering the fact that American producers will concentrate on Asian markets, the increase in production will be so considerable that it will be easier to conclude a contract.

This spectacular increase in LNG export from North America will also be ensured by Canada. If all the projected liquefaction terminals planned in the country are actually commissioned, it will become the global leader in supplies. All the announced projects make it possible to sell huge amounts of gas – over 117 bcm per year[54]. Despite the announced commissioning of some projects in the second half of this decade, IEA did not take into account the extra amount of gas from Canada on the world market by 2019. This probably results from the fact that investors do not declare in official documents what they really plan to do. Probably the possible delays which could result in postponing the majority of investment until the beginning of the next decade are connected with the general tendency to slow down or withhold many energy projects in the extraction and transmission sectors.

Table 10. Canada: LNG export terminals

Project	Production capacity (bcm/yr)	Year of commissioning (forecast)
Kitimat LNG	6.8	2018
LNG Canada	16.32	2021
Pacific NorthWest LNG	16.32	2019
Prince Rupert LNG	19.04	2023
WCC LNG	20.4	2024
WoodfibreLNGExport	2.86	2017
Triton LNG (FLNG)	2.72	—
Aurora LNG (STAGE I)	32.64	2023–2028
Total:	117.1 bcm/yr	

Source: IGU: World LNG Report - 2015 Edition.

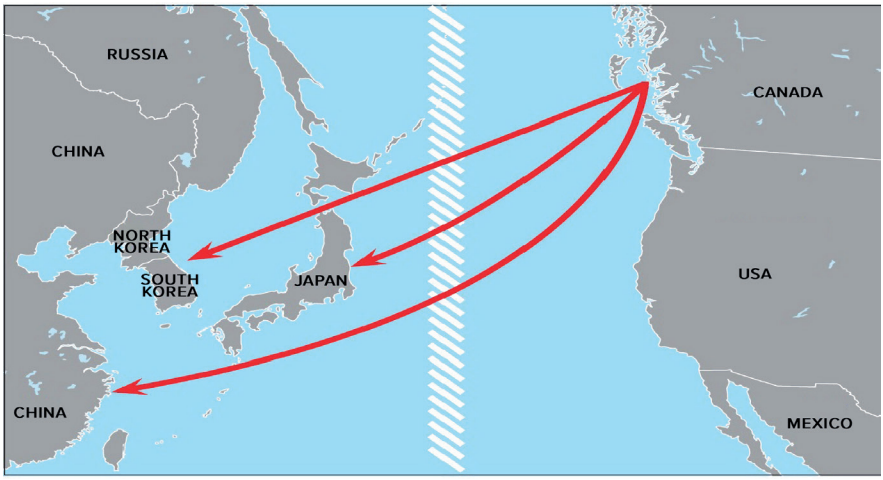
Some new installations are planned on the Western Coast, in British Columbia. Just like export from the US, most of the export will go to Asia-Pa-

[53] Ibidem, p. 157.

[54] IGU: World LNG Report – 2015 Edition. Data of Gas Medium-Term Market Report 2014 and IEA 2014 forecast the potential of 156.6 bcm/year. This data, however, is older, so the data from IGU should be considered as more accurate.

cific markets. If so, many producers assume sale on a single market, so oversupply of the resource is more probable. Then, it can go to other consumers, first of all in the European Union. That is why it may happen that Canadian liquefied gas will be sold in EU countries, delivered through the Panama Canal[55].

Map 5: LNG terminals in Canada designed with Asian markets in view



Source: P. Turowski, *Bezpieczeństwo dostaw gazu dla Grupy Wyszehradzkiej i pozostałych państw Unii Europejskiej [Security of gas supplies to the Visegrad Group and other EU countries]*, "Bezpieczeństwo Narodowe" quarterly, BBN, no. 30(2014), p.127, https://www.bbn.gov.pl/pl/wydarzenia/5731,quarterly-quotBezpieczenstwo-Narodowe-nr-30quot-25-lat-polskiej-strategii-bezpi.html (accessed: 03.08.2015).

Some African countries also serve as important LNG producers. These are particularly Nigeria and Algeria: the two biggest LNG producers in Africa. Both countries have the largest confirmed natural gas deposits in Africa (4.5 trillion m^3 in Algeria and 5.1 trillion m^3 in Nigeria). Both Nigeria and Algeria are very interesting from the European perspective, since they are the greatest African suppliers of LNG to Europe. Algeria is especially significant, as almost 90% of its export goes to Europe. Both countries plan to extend the existing LNG terminals or build new ones. This means that the export potential of the two countries is going to grow. This will be most beneficial for Asia, but also for Europe. But Africa is not only Nigeria and Algeria. It also includes new potential producers such as Mozambique or

[55] See P. Turowski, *Bezpieczeństwo dostaw gazu dla Grupy Wyszehradzkiej i pozostałych państw Unii Europejskiej [Security of gas supplies to the Visegrad Group and other EU countries],* op. cit. p. 126.

Tanzania. Gas deposits in Mozambique have even 2.9 trillion m^3 gas (not much less than deposits in Norway, which allow the export of approx. 100 bcm gas a year[56]). In Tanzania the deposits are smaller, nearly 1 trillion m^3 gas[57]. If all the pending projects of liquefaction terminals are carried out, both countries in Eastern Africa will supply more than several dozen bcm LNG per year starting with the middle of the 2020s. Out of the three planned terminals, we only know the capacity of one. It is really enormous – more than 27 bcm of liquefied gas a year. Although investors declare the project will be completed in three years, the IEA estimates it will be commissioned in five or six years at the earliest[58]. Due to the geographical location and optimum length of transport routes, new producers from East Africa may become the suppliers of gas to European Union countries, including Poland, to South and Central America, and to Asia-Pacific markets. In the latter region, India may be the most interested in purchasing LNG, as the freight costs will be the lowest[59].

Iran should also be taken into consideration. The recent relaxation of the political situation provides excellent opportunities for the return of Iranian oil and gas to world markets. Data from 2013 show that Iranian deposits of oil amount to 157 billion barrels, which makes them the world's fifth largest deposits. The confirmed resources of natural gas are even more impressive. It is estimated that Iran has deposits with almost 34 trillion m^3 gas, which accounts for nearly 1/5 of all the deposits of gas on earth and makes the Iranian gas deposits the largest in the world. So potentially Iran can become one of the most important exporters of oil and gas in the future. The problem is the construction and development of the infrastructure necessary for the export of resources. The construction of infrastructure may prove to be particularly difficult. To do this, Iran needs capital, Western technology, and time. However, if relations between Western countries and Iran indeed become normal, Iranian LNG may flow to Europe or to Asia within 5 years.

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[56] *BP Statistical Review of World Energy, 2015*, op. cit., p. 29.

[57] *Gas Medium-Term Market Report 2014*, *IEA 2014*, op. cit., p. 161.

[58] Ibidem, pp. 162-163.

[59] Ibidem, pp. 161-164.

CHAPTER SIX

Potential of the Świnoujście LNG terminal

The term 'construction of the Świnoujście LNG terminal' can be understood from a broad or narrow perspective. In the narrow meaning it is the investment concerning the very construction of the LNG terminal, i.e. the complex of structures, buildings, and installations used to receive liquefied natural gas from the wharf, store it, and re-gasify it. In the broader meaning, it is the construction of an LNG terminal, the construction of a breakwater and extension of the external dock[1], the construction of a gas pipeline with a diameter of 800 mm and length of 80 km,[2] and the wharf where vessels carrying LNG can moor[3].

The terminal is being constructed in Świnoujście commune on Wolin island. The installations of the LNG terminal cover an area of 48 ha and are located on shore, 750 m away from the coast. The breakwater is 3 km long and is located east of the existing breakwater that is part of the infrastructure of the Świna river port. The gas pipeline connecting the terminal with the national transmission network will run to a gas compression station in Goleniów. In the first stage of construction, the terminal will be made of two cryogenic tanks, each with a capacity of 160 thousand m^3 LNG. The re-gasification process will use *Submerged Combustion Vaporizer* technology. The technology involves changing the state of LNG in a system of pipes submerged in heated water. Annual re-gasification capacity after completion of

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[1] It will provide free maneuvering possibility to tankers that supply LNG thanks to the breakwater; the port in Świnoujście will be able to expand the range of activity, because the breakwater will also be accessible for other ships: two out of six stations will be designed for tankers, and the other will be used by other vessels in the future. The investment was carried out by the Maritime Office in Szczecin.

[2] The investor is Transmission Gas Pipelines Operator Gaz-System S.A.

[3] The investment involves the construction of a ship station including infrastructure necessary for mooring LNG vessels, such as a navigation security system. The ship receiving station will be located in a new external port, in which tankers will be moored and unloaded. Liquefied natural gas transported by ships will be delivered to the terminal through a gas pipeline connecting the terminal with the wharf. The Management Board of Szczecin and Świnoujście Sea Ports is responsible for his part of investment.

the 1st stage will be 5 billion Nm^3. It is assumed that after commissioning, the terminal will be ready to reload up to 5% of the received LNG loads to tank trucks; loading will be possible at two out of three stations (one station will be used as a reserve).

In the 2nd stage of terminal construction, a third tank will be built, probably[4] also holding up to 160 thousand m^3 LNG; the terminal's re-gasification capacity will increase up to 7.5 bn Nm^3 a year; and investment will be carried out to increase the possibility of the terminal providing extra services to its clients or the clients of its clients. The investor is Polskie LNG S.A. company, which is a 100% subsidiary of transmission pipelines operator Gaz-System S.A. The basic service provided by the LNG terminal in Świnoujście will be re-gasification of LNG. Stage 1 of the terminal construction will also allow the provision of the following:

1. Loading LNG on tanker trucks[5].
2. Off-take of LNG from ships.

6.1. Perspectives of using the new functionality of LNG terminals

Depending on the location and function of the terminal, the economic situation, the existing gas infrastructure, environmental regulations, and/or the ownership structure, terminals all over the world may provide extra services or products apart from the basic re-gasification service, such as: loading LNG on tanker trucks, loading LNG on rail tankers, bunkering LNG, "tank-vessel" loading, storage or long-term storing of LNG, supplying useful heat, supplying cold, or supplying electricity. Some services are determined by location, e.g. cold can be supplied if there is a nearby consumer of the product. Some are determined by the market situation, e.g. supplies of energy can be unprofitable due to low energy prices on a given market, or very well developed gas and road infrastructure, which neutralizes the possibility of providing LNG loading services on rail tankers. In addition, it must be stressed that when a terminal already exists or its construction is advanced, adding some services will be very difficult or impossible because of technological and construction solutions, e.g. supplying electricity and heat from co-generation if there are already other re-gasification solutions at the terminal.

This chapter presents the possibilities of the LNG terminal in Świnoujście providing services for third parties other than re-gasification of LNG.

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[4] At the moment of submitting the book for print, the final decision had not been made.

[5] Hereafter also: tanker trucks.

Given the scope and length of the analysis, at least two aspects will be disregarded in it:

1. The price of LNG delivered by ships to the terminal, especially with reference to the competition of pipeline gas, as well as natural gas from other sources (Kaliningrad[6], Odolanów, Grodzisk Wielkopolski[7], or Łaziska Górne[8]).

2. Costs/tariffs of re-gasification and other services the terminal can provide. Still, some factors that have an influence on the tariffs applied at the terminal should at least be outlined.

The competitiveness and demand for services offered by the terminal are not only the result of the very price of LNG offered as a carrier of energy, but also of the location and the prices (tariffs[9]) of the services provided, mainly affected – just as in the case of most infrastructure investments – by investment costs. The highest investment costs for constructing an onshore terminal are the tanks used for temporary storage of LNG until the moment of its re-gasification or dispatch to different maritime, rail, or road transport.

On the chart the LNG terminal in Świnoujście is marked in red, small-scale terminals are marked in green, and floating terminals (FSRU) in dark blue. The division into small terminals and floating or onshore (big) terminals is important, because in order to make appropriate comparisons they should not be considered on the same level and in the same group. Floating terminals are an alternative to onshore terminals, so they can, and in some cases should, be compared.

The mean capacity of tanks at European LNG terminals is 357 thousand m^3 and is higher than the capacity being built in Poland, 320 thousand m^3. Capacity serves a certain purpose which, generally, in the vast majority of European terminals (with the exception of some Spanish terminals which

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[6] In Kaliningrad Oblast an installation was located to liquefy gas from the main delivered to this part of the Russian Federation via a gas pipeline running through Belarus and Lithuania. At the moment, its liquefaction capacity is up to 100 tons LNG a day in 2016; after the extension, capacity will increase up to 150 tons a day.

[7] Odolanów and Grodzisk Wielkopolski are two nitrogen rejection units that remove nitrogen from natural gas, ensure that the gas meets the standards of high-methane gas, and enter it into the national transmission system. LNG is generated as a side product of helium production. The total annual volume of LNG production in both installations is about 40 million Nm^3.

[8] LNG Silesia from Łaziska Górne is also an LNG producer, specializing in the production of LNG based on methane from a coal mine. Annual production capacity of LNG Silesia is approx. 5 million Nm^3.

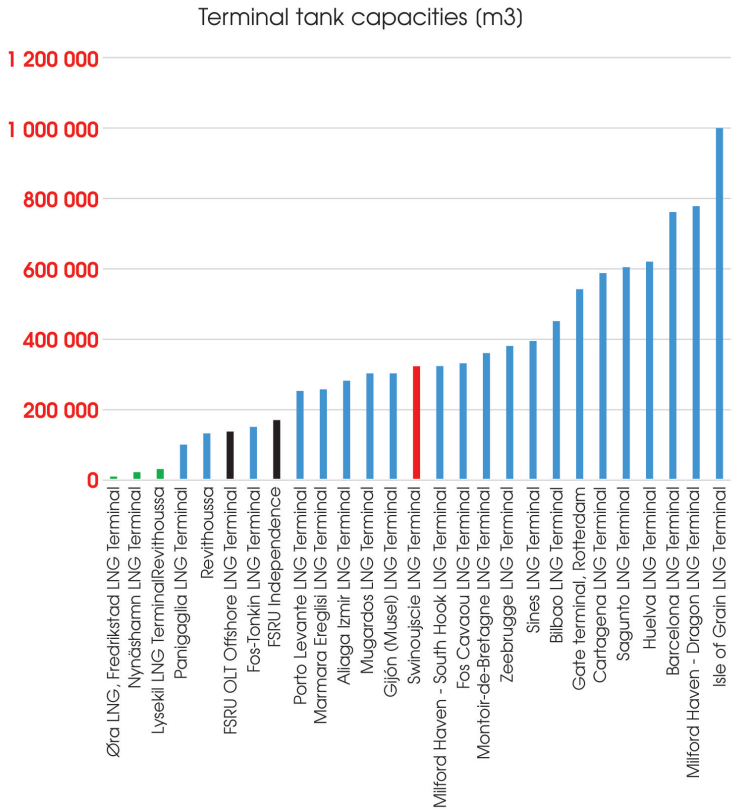
[9] Tariffs (prices for the customer) for the services provided by the terminal are approved by regulatory offices; depending on the legal system, they can be fixed or established as maximum prices, with various non-discriminatory discounts or rebates possible.

also serve the role of gas storage facilities) is connected with re-gasification services.

Below (Chart 8) we present the rate of re-gasification power per 1 m^3 of newly built storage capacity. This is the maximum efficiency of re-gasification achievable for the terminal with regard to one unit of capacity. The higher the rate, the greater the flexibility of re-gasification by the terminal, and the lower the capital costs connected with the re-gasification of 1 m^3 LNG.

For the Świnoujście terminal, the rate is 15,000 Nm^3/1 m^3 LNG, which means that using the full re-gasification power of the terminal (5 bn Nm^3 a year), thanks to having 1 m^3 tank capacity, the terminal will be able to enter 15,000 Nm^3 natural gas into the transmission system. For comparison, the mean of the European terminals is 23,300 Nm^3/1 m^3 LNG, which means that in comparison to the vast majority of European terminals, Świnoujście

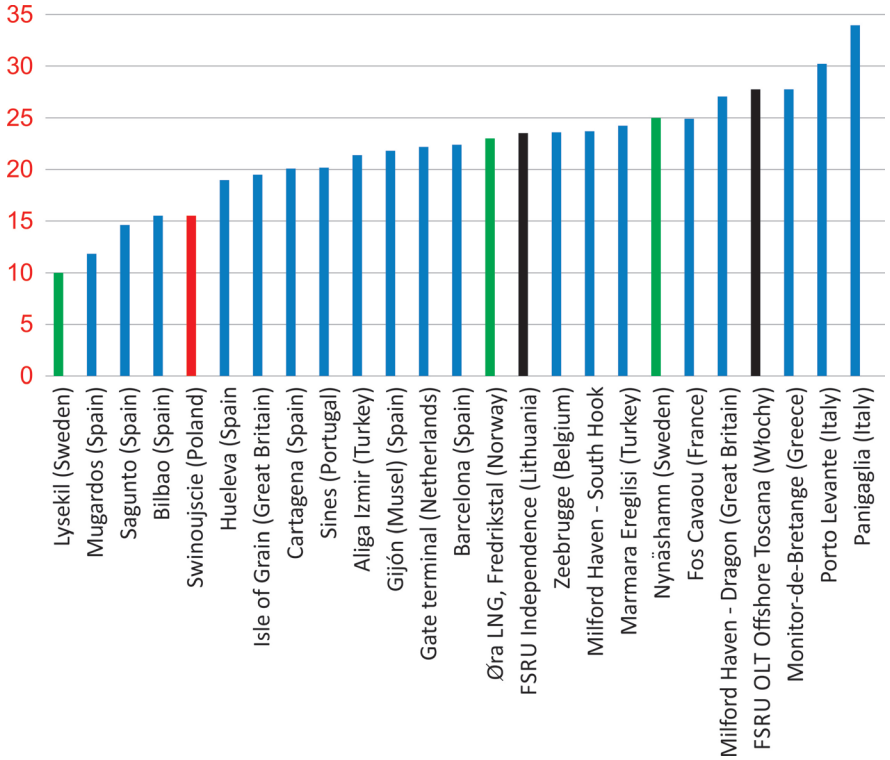
Chart 8. Tank capacities in European LNG terminals



Source: Original study based on: *GasInfrastructure Europe*.

has either too high a storage capacity in relation to its re-gasification rate or too low a re-gasification rate in relation to storage capacity. This will be one factor influencing the cost competitiveness of the Świnoujście terminal with regard to other terminals. Higher expenditure for the construction of LNG storage capacity (in terms of the terminal's re-gasification efficiency) rather than expenditure in other, more efficient terminals will be reflected in the re-gasification tariff. Higher investment expenditure is connected with the costs involved in the re-gasification tariff, i.e. amortization, real property tax, cost of capital, or renovation reserve (expressed as a proportion of the investment value). Other factors connected with tariffs at the Świnoujście terminal and other LNG terminals in Europe are e.g. the age of other European terminals, or the technology of re-gasification. Functioning terminals which have already been more or less amortized will be able to apply lower rates for re-gasification than the one in Świnoujście. The ORV re-gasification technologies applied in most European terminals involve lower operating costs of re-gasification than the SCV used in Świnoujście.

Chart 9. Re-gasification capacity / m³ of terminal tank capacity



Source: Original study based on: *GasInfrastructure Europe*.

Remembering this, and disregarding different proposals for so-called socialization[10] of the costs of a functioning LNG terminal, the terminal in Świnoujście should take advantage of the possibility of providing services other than re-gasification to the greatest extent possible. These services will ensure extra profits and will improve the financial results of the terminal on the one hand and allow the lowering of tariffs (prices) for LNG re-gasification on the other. After completion of the 1st stage of construction, the provision of extra services will be possible. Below, we present a description and analysis of the services that can be provided by the LNG terminal after its extension to 7.5 bn Nm^3 of re-gasification capacity as part of the second stage.

6.1.1. Loading LNG on tanker trucks

This chapter was written with the assumption that LNG would be distributed within Poland only. Although it must be said that in the case of an adequately efficient LNG trade organization, taking into consideration the distance from other existing LNG terminals (Rotterdam and Zeebrugge) it is possible to send certain volumes of LNG to Mecklenburg, Brandenburg, or Schleswig-Holstein (areas located closest to the terminal in Świnoujście and far enough from the terminal in Rotterdam) or even to Denmark. The *sine qua non* of international development is offering medium supply competitive enough in comparison to other suppliers or suppliers of other media[11]. Building a tunnel under the Świna river would be a factor promoting the penetration of markets in eastern German lands. It could be used for the heavy transport connected not only with the LNG terminal but also with the whole Świnoujście port. Loading LNG on tanker trucks is connected with supplies of LNG like:

a) rail fuel,

b) providing gas for areas or customers not connected to the gas grid yet, as a substitute for other fuels,

c) fuel safeguarding the gas supply to certain clients in case of disturbances in the gas supply (covering the risk of crisis risks occurring).

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[10] Socialization of the terminal costs is connected with the fact that the only entity really covering long-term costs of the LNG terminal at the moment is PGNiG S.A., with a contract for 3.6 bn Nm^3 re-gasification capacity of the terminal. Thus, only this entity incurs the costs of diversifying gas supply to Poland, which – taking into consideration the liberalizing natural gas market in Poland – causes financial encumbrances that reduce the competitiveness of PGNiG as compared to other companies. Regardless of its final form, socialization of costs will aim to distribute more evenly the costs connected with the functioning of the terminal among all the participants of the gas market in Poland.

[11] Light heating oil, heavy heating oil, propane.

Table 11. SWOT analysis of LNG loading and transport on tanker trucks

Strengths	Weaknesses
– the most flexible form of distribution of LNG[12] – no infrastructure barriers connected with transportation of fuel supplies to any place in the country	– problems with clearing the losses of gas during the transport as a result of natural re-gasification[13] – problems with billing of different kinds of LNG transported at different temperatures and pressures[3]
Opportunities	Threats
– EU strategy concerning low emission transport and the development of sales of fuel for trucks and buses[14] – development of sale connected with demand for LNG to local distribution networks in areas without gas supply	– development of transmission and distribution gas pipelines – competition of supplies from the Kaliningrad Oblast – in the case of low crude oil prices, unattractive prices of LNG to be distributed from the Świnoujście terminal in comparison to LPG and light heating oil – ERO tariff policy

Source: Original study.

It is also possible to deliver LNG by trucks as a bunkering fuel. This issue is discussed in the section on bunkering LNG.

[12] A truck with LNG can reach any place in Poland within 24 hours, with the exception of the summer high temperatures period (when temporary limitations of heavy vehicle traffic are introduced) or periods of heavy snowfall in winter (when it is impossible to ensure the passability of all roads quickly enough).

[13] A phenomenon that cannot be avoided either in the process of transport or during storage is the transition of some of the gas into a gaseous form (*boil off gas*). The extent of this phenomenon depends on the size of the tank, the temperature of LNG, the pressure in the tank, or the ambient temperature. In the case of transportation by trucks, it is approx. 0.15% of the volume a day. For the customer it is a loss, because the gas cannot be taken off as LNG, but for the supplier it is no loss, because gas in the gaseous form remains in the tanks and should be removed from it from time to time using a special installation.

[14] Temperature and pressure are important for transporting LNG by trucks and by rail. LNG can be transported at –153°C with the pressure 3 bar, –130°C with the pressure 8 bar, and –110°C with the pressure 18 bar. Higher pressures of LNG in the tank inhibit the process of transition into the gaseous form of LNG at higher temperature (if we closed a pot and applied a pressure higher than the atmospheric pressure to the water, the boiling temperature would no longer be 100°C but respectively higher). If a customer wants to receive LNG from two suppliers and they offer gas with different temperatures, after the reception of gas with the higher temperature the re-gasification process in the customer's tank would be considerably quicker. Examples of such suppliers that supply LNG in Poland with different temperatures are Odolanów (ca. –160°C) and Kaliningrad (–130°C).

[15] Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructure, OJ EU L 2014.307.1 of 22.10.2014.

The contractual and technological possibilities of dispatching LNG to tanker trucks need to be determined, too. In that case, two parameters apply. The first is the contractual parameter, i.e., in the case of the LNG terminal in Świnoujście the ability to receive 5% of gas volume by tanker trucks (95 thousand tons LNG a year[16] = 130 thousand m^3); the other is the technological parameter, i.e., the possibility of dispatching to tanker trucks 90 m^3 LNG/h. Assuming that the active capacity[17] of a tanker truck is 45 m^3 and taking into account the time of a full filling cycle (driving to the filling station, connecting the truck, filling, disconnecting, driving away), we obtain 90 m^3 LNG/80 minutes or 67.5 m^3 LNG/h. In addition, assuming the stoppage time of the LNG pump connected with its checks and repairs on average 7 days a year, from the technical point of view the terminal in Świnoujście is able to dispatch to tanker trucks 565.4 thousand m^3 LNG a year, i.e. more than 3.3 bn Nm^3 gas. This means that theoretically, if market demand is high enough, the terminal could additionally dispatch to tanker trucks more than 60% of its re-gasification capacity even after the 1st stage of construction. Thus, the actual capacity of reloading LNG converted into re-gasified gas would be approx. 8.3 billion Nm^3.

Furthermore, the Świnoujście terminal itself may become a refuelling place for trucks transporting LNG with LNG. Instead of diesel oil, trucks transporting LNG would be filled with LNG[18]. Assuming the active capacity of a truck of 45 m^3, dispatching only the assumed 95 thousand tons LNG and using 0.5 m^3 LNG for the cycle between fillings, we obtain a dispatch amount of ca. 1,500 m^3 LNG a year. The LNG terminal could offer this service at minimum expenditure connected with adjusting the infrastructure (at the moment this is technically impossible). However, in the first period of development of the LNG market for transport purposes, the lack of an appropriate number of filling stations will make cryocontainer fleet operators use *dual fuel*[19], i.e. simultaneous combustion of diesel oil and natural gas. In that case, the volume of refueling in the case of dispatching 95 thousand tons a year is 750 m^3 a year.

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[16] Portal Polskie LNG, http://www.polskielng.pl/fileadmin/pliki/open-season/pl/Procedura_udostepniania_Terminalu_LNG_w_ Swinoujsciu_2009.pdf (accessed: 4.07.2015).

[17] The capacity of a truck is 53 m^3 but for safety reasons it should not be filled up to more than 85%, which means 45 m^3 active capacity.

[18] There are already trucks available on the market that are 100% adjusted to being propelled with LNG – for example, IVECO Stralis.

[19] A *dual–fuel* installation is a system installed in a diesel engine that introduces natural gas into the cylinder, thanks to which the consumption of more expensive and higher-emission diesel oil decreases by approx. 50%, which is replaced by ecologically cleaner and cheaper natural gas. In Poland there are 5 producers of such installations. The majority of the installations are exported, as they are among the most modern in Europe.

Loading LNG on tanker trucks connected with supplies of LNG as traditional fuel

The transport structure in Poland is dominated by road transport, which is the least energy efficient and emits the greatest amount of greenhouse gasses. The consumption of diesel oil for 100 tkm in the case of road transport is ca. 250% higher than in the case of railroad transport and over 300% higher than in the case of inland ships. Road transport accounts for over 80% of carriage of commodity transport and long-distance transport of people[20]. As a result of extending the network of roads (highways or expressways), the high share in road transport will additionally grow. At least 10 years of investment in railroad infrastructure that are well thought out and significant from the capital point of view will be needed to stop the growing trend of road transport of goods[21]. Thus, the main volume of LNG sales, taking into account the use of this fuel on land, will be connected with road transport.

Table 12. Number of buses in Poland by size and age

	Buses	
	Up to 15 seats	16 – 45 seats
Up to 1 year old	20	814
1 – 2 years old	30	419
2 – 3 years old	23	457
4 – 5 years old	70	1,365
6 – 7 years old	149	1,886
8 – 9 years old	285	2,887
10 – 11 years old	214	2,737
12 – 15 years old	733	6,475
16 – 20 years old	920	4,680
21 – 25 years old	1,334	2,862
26 – 30 years old	1,655	3,486

Source: Original study.

On the one hand, more carriage is going to occur in Poland as a developing economy, and on the other hand, the country is obliged to reduce the emission, not only of CO_2, but also of dust or sulfur or nitrogen compounds. These two can be reconciled by using fuels and transport solutions that reduce the emission of harmful substances. One such solution is the use of natural gas as a fuel (alone or in dual-fuel installations that involve the com-

[20] Calculated on the basis of data from Central Statistical Office, http://stat.gov.pl/obszary-tematyczne/transport-i-lacznosc/ (accessed: 8.07.2015).

[21] Author's analysis based on data from: Ministry of Transport and Maritime Economy *Strategy of Transport Development until 2020 (forecast until 2030)*, Warsaw, 22 January 2013, and the Multi-Annual Rail Investments Programme until 2015 with the 2020 perspective, adopted by the Council of Ministers on March 13, 2015.

bustion of diesel oil and natural gas at the same time) instead of diesel oil. For natural gas and other alternative fuels to become popular, alternative fuel infrastructure is necessary, as provided for e.g. in the Directive of the European Parliament and of the Council 2014/94/EU of 22 October 2014 on the deployment of alternative fuels infrastructure.

Regardless of the form (liquefied or compressed) in which the gas fuel is used by vehicles, the potential of market growth connected with low-emission economic development is great. On the basis of experiences from other EU countries (France, Germany, Italy), it can be anticipated that the market will mainly develop in terms of passenger transport.

The number of buses older than 15 years[22] in the context of fleet replacement potentially subsidized as part of Low Emission Economy Plans ensures a high potential for development of the market of natural gas-fueled vehicles, which could be supplied as part of new investments in buses. Buses between 3 (after the end of the warranty) and 10 years old (in good working condition in terms of relevant technical requirements) are the market for dual-fuel installations.

The relatively most attractive group of buses is city buses, because it is easiest for them to organize fuel supply with sufficient daily volumes at a minimum number of filling stations (at bus depots). In addition, city buses (as compared to school buses) have high mileages and high fuel consumption (see Table 13).

Table 13. Number and average mileage of city buses

	Average mileage of a bus within	
Number of city buses	a year	a day
11,518	70,948	194

Source: *Rocznik Statystyczny GUS*.

After buses, trucks will be subject to total or partial (dual-fuel) conversion (see Table 14).

Data of the Central Statistical Office shows that just as in the case of buses, the number of trucks over 10 years old in Poland is the factor that determines the high development potential of the market for vehicles fueled by natural gas, which could be supplied as part of investment in new

[22] It must be emphasized that some of the buses older than 20 years have probably already been immobilized for a long time but are still included in Central Statistical Office (GUS) statistics. Between data of the Central Vehicles and Drivers Register [Centralna Ewidencja Pojazdów i Kierowców, CEPIK] and data of insurance companies concerning third party insurance there is a difference of 2.5 million vehicles (the higher number is in CEPIK), and the number presented by GUS is even higher than that of CEPIK.

vehicles. And again, trucks between 3 (after the end of the warranty period) and 10 years old (in good working condition in terms of relevant technical requirements) are the market for dual-fuel installation.

Table 14. Number and age of trucks

	Trucks	
	over 1,500 kg load capacity	truck tractors
up to 1 year old	9,495	25,657
1 – 2 years old	6,264	13,193
2 – 3 years old	6,040	7,853
4 – 5 years old	21,892	23,477
6 – 7 years old	32,279	42,885
8 – 9 years old	30,938	28,515
10 – 11 years old	30,033	21,865
12 – 15 years old	92,850	43,074
16 – 20 years old	90,212	28,284
21 – 25 years old	84,554	22,548
26 – 30 years old	66,155	9,168

Source: *Rocznik Statystyczny GUS*.

The development of CNG/LNG filling stations and the number of vehicles will also take place in transport companies and their facilities. The larger the company, the higher the probability of using gas fuel. Some business entities have even now established bigger or smaller CNG filling stations in their facilities[23].

Table 15. Number of companies by fleet size

Companies with the number of trucks and truck tractors:					
5 or below	from 6 to 9	from 10 to 19	from 20 to 49	from 50 to 99	100 or more
325	706	1,680	893	163	80

Source: *Rocznik Statystyczny GUS*.

Entities with fleets exceeding 20 vehicles parked in a single place (or in close proximity) can decide to build CNG stations in a way beneficial for them. Entities that have more than 50 vehicles, however, should think about building LCNG, not CNG stations[24]. But the number of vehicles or the size of the company alone are not sufficient data to correctly evaluate the LNG/

[23] *Pierwsza stacja CNG w Kaliszu [The first CNG station in Kalisz]*, http://cng.kalisz.pl/ (accessed 29.07.2015).

[24] An LCNG station is an installation to which LNG is delivered and which can be used for refueling with both LNG and CNG (the product of re-gasification of LNG).

CNG market. Due to the technologies used, the number of tanks and the relatively short distance that can be covered after a single filling, the distance structure of transported cargoes is important (see Table 15).

Regarding the capacity of tanks, for 100% CNG-fueled vehicles the range of operation is 150 km, for vehicles with *dual-fuel* installations, the range is 100% higher[25] (maximum 300 km, and for LNG vehicles, up to 800 km). As we can see in Table 6, 80% of the cargo in national transport is transported not farther than 150 km, which is over 30% of the total transport performance. Assuming the use of 0.026 Nm^3 needed for carrying 1 ton for 1 km (in a *dual fuel* vehicle), transport up to 150 km and a 14% ratio of conversion into natural gas[26] we obtain a market potential of 126 million Nm^3.

Table 16. Domestic road vehicle cargo transport – distance zone structure

	thousand tons	million t-km
0 – 49 km	609,946	10,109
50 – 149 km	265,907	22,898
150 – 499 km	224,308	57,501
500 or more	16,840	9,812

Source: *Rocznik Statystyczny GUS*.

LNG/CNG can be used as a traditional fuel for railroad transport, either propelling engines completely (exclusive use of natural gas) or partially (*dual-fuel* installations). For logistic reasons (the number of LNG/CNG filling stations) and due to the need to reduce operating risk (to ensure continuous work), mainly dual-fuel installations can be expected during the first stage of development of this part of the market, which ensure normal work of the engine in case of natural gas shortages for any reason. PKP Cargo S.A. Group is the largest cargo carrier in Poland. The fleet is amortized to a large extent. The mean age of the company's electric engines is 29 years, and diesel engines, 32 years[27]. The age of the engine fleet is an advantage for the LNG market, because as part of engine replacement, LNG or dual-fuel engines can be purchased. As of June 30, 2013, the Group had 1,161 electric engines and 1,292 diesel engines[28]. Dual-fuel systems could also be installed as part of modernization of the engines PKP Cargo now has. For example, on May 6, 2013, the Company signed a contract for the modernization of 30 diesel engines series SM48. The contract price will be a total of PLN 178.7 million gross[29]. Raising

[25] *Dual-fuel* vehicles use the mixture of about 50% natural gas and 50% diesel oil.

[26] An analogy to LPG market was used, on which 14% cars are equipped with gas installations.

[27] *Prospekt emisyjny PKP Cargo S.A. [A prospectus of PKP Cargo S.A.]* p. 36.

[28] Ibidem, p. 39.

[29] Ibidem, p. 102.

the subject of using a more ecological and economical fuel, natural gas, could give measurable economic benefits both to the carrier and to the fuel supplier. Motors installed as part of the overhaul of diesel engines[30] could be fueled with LNG. In the case of CNG, because of the higher volume and weight of the cylinder, the engine could possibly have a small carriage attached with CNG cylinders. Vehicles could be filled with CNG and LNG at LCNG stations.

In Poland, PESA[31] and Newag[32] companies offer new engines or overhauls, and cooperation with those companies could have a synergistic effect at different levels: economic, ecological, transport security, and social. Furthermore, there is a tendency for most carriers to use engines more efficiently, which means higher average daily work of the engine. For example, in the case of PKP Cargo Group, the average daily distance covered was 258 km in the first half of 2013 and 249 km a day in 2012: 149 km for diesel engines and 271 km a day for electric engines, whereas in 2011 and 2010 the average daily distance covered by an engine was 252 and 235 km, respectively[33]. For economic reasons, there is greater market potential in the modernization of engines than in the purchase of new ones. The average cost of modernization of one engine is approximately 1 million euros (depending on the model and scope of modernization), and a new engine is about 4 million euros[34].

In order to take advantage of railroad market opportunities, not only carrier enterprises (fundamental for the development of using LNG as a fuel for rail transport) but also the suppliers of engines and fuel should take part in research and development, testing, and implementation. Certificates of approval from the relevant institutions, particularly from the Office of Rail Transport, may be needed. It must be highlighted that the development of efficient and lower emission rail transport is provided for by both the EU[35] and national documents[36]. Assuming the installation of *dual-fuel* systems in 20% of diesel engines in the PKP Cargo Group, and technical data[37] for an

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[30] *Lokomotywy spalinowe [Diesel engines]*, http://www.newag.pl/oferta/lokomotywy-spalinowe/ (accessed: 18.07.2015).

[31] *Lokomotywy spalinowe [Diesel engines]*, http://www.pesa.pl/index.php/pl/produkty/lokomotywy/ (brak daty)

[32] *Spalinowe zespoły trakcyjne[Diesel-fueled trains]*, http://www.newag.pl/oferta/spalinowe-zespoly-trakcyjne/ (brak daty).

[33] *Prospekt emisyjny PKP [A prospectus of PKP]*, op. cit., p. 133.

[34] Ibidem, p. 133.

[35] Directive of the European Parliament and of the Council 2014/94/EU..., op. cit.

[36] Ministry of Transport and Maritime Economy, *Strategy of Transport Development until 2020* ... op. cit., and (forecast until 2030), Warsaw, 22 January 2013, and the Multi-Annual Rail Investments Programme until 2015 ... op. cit.

[37] Capacity – 708 KW (962 KM), diesel oil consumption in the neutral gear – 4.5 l/h, unit fuel consumption 198 g/kWh.

SM 42 engine after modernization[38], 50% replacement of diesel oil with natural gas, and the work of an engine for 2,000 h a year, we obtain consumption of 40 million Nm^3. And last but not least, Cargo Group is the biggest but not the only carrier in Poland. A properly profiled commercial offer combined with the development of infrastructure for filling engines with LNG/CNG ensures faster replacement of the rail fleet in future and provides an interesting prospect for the development of liquefied gas sales.

Loading LNG on tanker trucks connected with supplies of LNG used as a fuel in providing gas to areas that do not yet have them

The construction of gas mains always (in the case of LNG installations, even more) involves certain factors:

a) currently used energy carriers: their availability, replaceability, and prices,
b) population density and demographic trends,
c) income of the population and entities in the area,
d) the kind of activity,
e) environmental regulations that are applicable at the moment and those that have already been adopted but are yet to come into force.

In 2013, the gas main in Poland was approx. 140 thousand km long, nearly 120 thousand km of which was distribution grid. At the end of 2013, the highest density of gas network was in three provinces: Małopolskie 148.7 km per 100 km^2 (higher than in 2012 by 11.0 km per 100 km^2), Śląskie – 134.0 (by 13.9 km per 100 km^2) and Podkarpackie – 106 (by 11.6 km per 100 km^2), and the lowest in Podlaskie – 7.2 (by 0.2 km per 100 km^2). In 2013, the total percentage of people in Poland who used the gas network did not change in relation to 2012 and was 52.4%. In towns, more than 72% of the total population used the gas network, while in rural areas, approx. 22%[39].

In 2013, household consumption of gas was almost 556 m^3 per user. In towns, it was over 505 m^3, and in rural areas, over 891 m^3. In comparison with the previous year, the consumption of gas from the mains rose by 1.4% (in towns by 1.3%, in rural areas by 0.8%). The highest Polish household consumption of gas from the mains per user occurred in Wielkopolskie province (810.9 m^3 per user), and the lowest, in Łódzkie province (347.2 m^3). In comparison to 2012, the consumption of gas from the main in towns rose by 6.7 m^3 per user, and in rural areas, by 6.8 m^3.

Installing gas mains in new areas should ensure the potential return of expenditure and fair profit for the entity that engages in such activity. Despite the theoretically high potential for building gas mains, including the construction of LNG re-gasification stations with a grid distribut-

[38] http://www.newag.pl/oferta/lokomotywy-spalinowe/ (accessed: 28.07.2015).

[39] Data on gas infrastructure comes from the yearbook 'Infrastruktura komunalna w Polsce w 2013 r.' *[Municipal infrastructure in Poland in 2013]*, Central Statistical Office, Warsaw 2014.

ing re-gasified LNG, as the aforementioned statistics show, many areas without gas lines do not meet the criteria of economic justification. The process of depopulation of villages and small towns[40] combined with the process of aging of the society in many cases means that the supply of gas mains to certain areas may not be economically profitable. The process of depopulation and aging is connected with the issue of revenue levels, which motivate the vast majority of inhabitants of communities without gas mains: 1. to use the cheapest energy sources (in rural and urn-rural communes the dominant carriers of energy are coal and wood)[41], 2. if it is possible to connect to a natural gas main and use it as a carrier of energy, the residents are either not interested at all in the offer or want it only as energy for heating their meals[42].

The level of income and the preferences concerning the structure of gas consumption is a broader problem that does not only affect rural residents. According to Eurostat[43], the median income per person in Poland in the years 2005–2012 rose from 2.1 to 5.6 thousand euros, so the income of an average resident grew from 20% to 33% of the European mean. The distribution of income is also important, illustrated among others by the Gini index of inequalities in income distribution[44]. In Poland in 2012, it was 30.9%, and the proportion of people at risk of poverty was 27%. According to Eurostat, in 2012, electricity, natural gas, and other energy carriers, the expenditure of an average household in Poland was 500 euros a year per person, 9% of total consumption expenses. For comparison, an average European household spent 700 euros per person – 4.5% of consumption expenses. At the moment, households' or economic entities' transition to natural gas from the most popular Polish fuel, coal, but without investing in energy saving, only results in higher costs as far as the economy is concerned.

The above-mentioned income and demographic factors mean that many areas will probably never be provided with gas lines. In some cases, investors' decisions will be influenced by public funds (the resources of the EU, National Fund for Environmental Protection and Water Management, or

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[40] *Monitoring rozwoju obszarów wiejskich [Monitoring of rural development]*, Forum Inicjatyw Rozwojowych Fundacji Europejski Fundusz Rozwoju Wsi Polskiej, Warsaw 2014.

[41] *Potrzeby i braki energetyczne społeczności wiejskich i podmiejskich w Polsce [Energy needs and shortages of rural and suburban communities in Poland]*, Forum Rozwoju Efektywnej Energii, Warsaw of 8.12.2010.

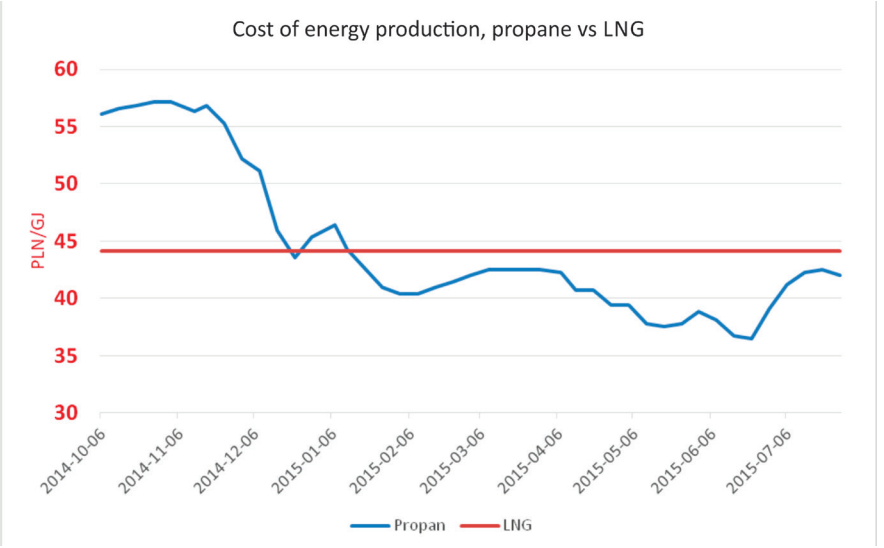
[42] This means statistical annual consumption of ca. 100 m^3 per household (based on data from PGNiG).

[43] Study by EU SILC.

[44] The Gini coefficient shows the society's income inequality. It may have values from 0 to 1, often expressed as percentage. The 0 index means full equality of income.

Provincial Funds for Environmental Protection and Water Management), which will fill the financial gap necessary for economic justification of the investments. However, such cases will rather be marginal than typical in Poland, first because of the indebtedness of Polish local authorities, second, because of priorities attributed to spending European resources in the future, and third, because the priorities of local authorities who in many cases have (in their opinion) more important activities and projects to carry out, plus the general attitude of local authorities connected with the fact that gas (or electricity) infrastructure should basically be a source of taxes[45] but should never be subsidized or promoted with lower taxation.

Chart 10. Cost of energy production, propane vs LNG



Source: Calculated on the basis of Chemline, Odolanów tariff.

Medium and relatively large energy consumers, currently using other carriers of energy, located in rural and urban-rural communes (preferably in commune administrative seats), and possibly also laying gas pipeline in the very places that are commune administrative seats, are an opportunity for developing the LNG market. In the case of clients with highly seasonal energy consumption (e.g. greenhouses or dairies), looking for other possibilities for sales of natural gas, e.g. through supplying gas lines to the area closest to the station, is an opportunity for developing

[45] Real property tax – Polish local authorities are mostly interested in tax on structures, fixed at 2% of the structure value.

the LNG market. This does not mean supplying gas lines to e.g. half or all of the commune.

Natural gas, including the LNG form, is losing its price competitiveness as a carrier of energy as compared to other carriers, given the low prices of crude oil (since the beginning of 2015), and in the case of highly seasonal clients, i.e. ones that consume relatively high volumes of fuel but only in winter time. In these cases, costs related to reserving gas pipeline capacity or fixed costs connected with LNG installations become the factor determining the loss of competitiveness of natural gas in favor of other fuels. In addition, we must not forget the possibility of easy use[46] of light burning oil, not only for heating purposes but also in railroad transport. Chart 3 presents the changes in costs of producing 1 gigajoule from propane and from LNG that a Polish consumer could have had since October 2014[47]. Assumptions for calculations: propane – price from Chemline listings for individual customers minus 20% discount (for business customers), net calorific value of propane 24.93 MJ/L; LNG – price at Odolanów PLN 1.803639/kg, total costs of re-gasification PLN 0.2 /Nm^3, net calorific value of LNG 38 MJ/Nm^3, cost of transport PLN 0.04/Nm^3/100 km, delivery of LNG within the distance of 300 km.

In the long run, we should expect the adjustment (reduction) of natural gas and LNG prices to the prices of oil derivatives, and for methane fuel to regain its price competitiveness. Remembering that LNG will be a more advantageous energy carrier for large consumers than light heating oil and propane, and estimating the volume of sales of LHO and propane for large consumers as 20% of the markets of those carriers (LHO[48] – 843 thousand m^3, propane[49] – 260 thousand tons^3 respectively), we obtain a combined potential of LNG sales at the level of 167.8 thousand tons.

Loading LNG on tanker trucks connected with supplies of LNG as fuel securing gas supplies to certain clients

For some clients that receive natural gas, it is important (for not only technological reasons) to ensure the continuity of supply. Examples of such clients are companies producing ceramic tiles, with furnaces for baking the product, or pharmaceutical warehouses, where temperatures suitable for the storage of

[46] This does not comply with tax law, but is common.

[47] The beginning of the heating season and the decreasing prices of crude oil on global markets.

[48] Raport Polskiej Organizacji Przemysłu i Handlu Naftowego za 2014 r. *[Report of the Polish Oil Industry and Trade Organisation for 2014]*, POPiHN, Warsaw 2015.

[49] Raport Polskiej Organizacji Gazu Płynnego za 2014 r. *[Report of the Polish LPG Association for 2014]*, POGP, Warsaw 2015.

pharmaceuticals are required. In these cases, supplies of LNG as a fuel for safeguarding reserve supply continuity are also needed on the market. A similar situation may take place in the case of big consumers, which is directly connected with section 6.1.2 of this chapter, i.e. transport of LNG in rail tankers.

Concluding the discussion of loading on tanker trucks, we need to point out the possibility of the terminal providing transport services, which could lengthen the logistic chain the terminal provides for. The main question in this case is whether such services provided by Polskie LNG would be competitive with reference to entities already functioning on the market. Due to the niche character and the possibility of appropriate combination of services (lengthening the value chain) and the establishment of a small lean logistic organization, this seems one of the possibilities of future activity of the terminal.

6.1.2. Loading LNG on rail tankers

Loading LNG on rail tankers is possible and justified in the case of large sales volumes. There are three cases from an economic point of view in which the conditions justify transporting LNG by rail:

a) having a gas consumer that has tank(s) with adequate capacity (minimum 3,000 m^3),

b) owning an adequately large tank or a reloading base,

c) having several large LNG consumers that have sidings or are located by railroad tracks.

The basic drawbacks of transporting LNG by railroad are the quality and density of the Polish railroad network[50], and the resultant low speed of freight trains[51]. Moreover, at the moment there are no clients large enough who are able to or express the intention to use such services.

The SWOT analysis clearly shows a good number of drawbacks to offering and developing this kind of service. But if the right clients are found, the provision of the service may actually be profitable. From the point of view of development of services provided by the Świnoujście LNG terminal, it would be best to find (in cooperation with PGNiG S.A.) such clients before making a final decision concerning the scope of extension of the terminal and its functionality in the 2nd stage of extension.

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[50] *PKP Polskie Linie Kolejowe [PKP Polish Rail]*, http://www.plk-sa.pl/dla-klientow-i-kontrahentow/warunki-udostepniania-infrastruktury-i-regulaminy/prawo-dostepu-do-infrastruktury-kolejowej/ (accessed: 1.08.2015).

[51] According to the data of PKP PLKi Team of Advisers TPR, in 2013 the mean speed of a freight train was 24 km/h.

Table 17. SWOT analysis of LNG transport by rail tankers

Strengths	Weaknesses
– possible transport of relatively big LNG cargo at a time[52] – cheaper than transport by tanker trucks on long routes	– freight trains going fast on rails in Poland – the need to incur substantial extra expenditure at the terminal to build the needed infrastructure – high expenditure for the purchase of tank cars for the whole train[53] – the need to build extra reloading infrastructure in the country – problem with the clearance of BoG – no price competitiveness of this kind of transport in the case of short routes (up to 250 km)
Opportunities	Threats
– back-up installations located in future at companies that are large consumers of natural gas – clients using LNG that will receive it in tank containers (e.g. for bunkering)	– extension of transmission and distribution networks – gas supply from the Kaliningrad Oblast by trucks

Source: Original study.

Loading LNG on rail tankers – having a gas consumer with high capacity tank(s)

The number of consumers (or more precisely, the number of receiving points[54] or locations of large LNG installations connected with high annual volumes of gas sales) that could potentially be interested in the construction of such installations is between 12 and 20 in Poland. Apart from the function of safeguarding continuity of supplies, such big tanker installations (just like the installations discussed further on) would, or at least could, serve the function of local LNG distribution centers from which the gas would be supplied to clients within a range of 200 km. The real demand for such installations in Poland can be estimated as 2-3 in the whole country.

Loading LNG on rail tankers – having a large enough tank or reloading base

If the owner or operator of an LNG terminal decides to invest in their own tank or reloading base, what should be considered first is technologies,

[52] Assuming the rail tanker's capacity of 102 m^3 LNG, tankers filled up to 90%, and LNG weight = 430 kg, the load capacity of a train is 1,600 tons, which equals 40 tankers and the possibility of carrying 2.1 million Nm^3 at a time (i.e., approximately 10% of Poland's daily consumption in the vacation period).

[53] The purchase (lease) of 40 cryogenic tanks is assumed.

[54] There may be more than one receiving point per consumer, e.g. Grupa Azoty has several plants in different places in Poland.

then locations, and then the target clients. All three factors are closely interconnected. If LNG was supplied to clients in tanks installed in container frames (tank containers), the siding would have to be adjusted to unloading full containers with LNG and loading empty containers on the train. In the case of supplies to clients in tanker trucks, large enough LNG tank(s) would need to be built to receive all the cargo brought by a shuttle train. Given the development plans for networks of transmission gas pipelines and distribution pipelines, there are 4 potential locations for such investments: Warmińsko-Mazurskie province (eastern part), Świętokrzyskie province, Łódzkie province (southern part) and Kujawsko-Pomorskie province (north-western part). At least in one location (Warmińsko-Mazurskie), the strong influence of the Russian supplier delivering LNG from Kaliningrad is likely. From the point of view of the operator of a LNG terminal, this option seems the most risky.

Loading LNG on rail tankers – having several big LNG consumers that have sidings or are located by railroad tracks

The content of this section partially overlaps with section a), because, first, the volume of a single supply would still be relatively large, and second, clients mentioned in section a) would not have to intend to build tanks at their premises to be used as regional centers of LNG logistics. The customers could be divided into two groups: the first is those who are interested in back up installations, and the other, those who are interested in LNG supplies as their basic energy carrier. The potential number of receiving points that can be operated by an entity applying this business model rises up to the range of 60 to 100. That model would reveal issues connected with the low speed of trains going along Polish tracks and the clearance of BoG, which in journeys of several dozen hours (from the moment of loading LNG to the moment of delivery to the last customer, plus the more customers in a single run[55]) or even more than 100 hours would be quite significant.

To conclude, it is worth stressing that the provision of services of loading LNG on rail tankers requires at the least a lot of active commercial work, and considering the issue more broadly, appropriate collaboration as well with PGNiG S.A, which is currently the only entity that has reserved reloading capacity at the Świnoujście terminal.

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[55] In logistics, this type of run is called a *milkrun* or *milkway* – starting from one point, reaching the needed points, and returning to the starting point. The task of logistics specialists is to manage transport so as to ensure that cargo reaches the customer(s) as quickly as possible and the transport is as cheap as possible.

6.1.3. LNG bunkering

The main factor creating a market for using LNG for bunkering is the coming into force of the sulfur directive applying to the Baltic Sea, the Danish straits, the North Sea[56], and the English Channel[57]. Currently, cargo and passenger ships mostly use HFO (heavy fuel oils), which accounts for more than 80% of the total demand for bunkering fuel. There are three ways a ship can reduce sulfur emissions:

1. The use of an appropriate drilling fluid[58].
2. The use of MGO[59].
3. The use of LNG fuel.
4. The use of other alternative fuels, such as hydrogen, biogas, or methanol.

In the first half of 2013, members of the ESN (*European Shortsea Network*, an informal agreement of institutions promoting short-sea shipping) carried out research among ship owners to find out about their plans for adjusting their fleets to the new requirements of the IMO. 33 shipowners (most with headquarters in Norway or Finland[60]) took part in the research.

All the participants declared they were planning to use MGO. This is connected with the ease of using the fuel and makes it possible to adjust the fleet quickly. 70% of the respondents said it was the only option they were thinking of. The other respondents declared they also thought of using drilling fluids for the currently used fleet. It was also indicated that drilling fluids are the preferred solution for vessels under 10 years old. According to the authors, the best solution for the newly built vessels is LNG, provided that the ships have regular routes and spend their whole operating time within the SECA[61].

The results of analyses conducted by DNVGL (*Shipping 2020*, August 2012) concerning the impact of the Sulphur Directive and other regulations of the IMO on shipowners' activity show that the share of LNG-fueled fleet is closely connected to its price. If the price is 10% higher than the price of HFO, 7–8% of new ships built in the years 2012-2020 will use LNG. LNG price 30% lower than the price of HFO will mean 13% of fleet with LNG. In the extreme scenario (price 70% lower than that of HFO), the rate will be even 30%.

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[56] East of 4° west longitude and south of 62° north latitude.

[57] East of 5° west longitude.

[58] A device that removes sulfur during the rinsing of fumes, which makes it possible to use cheaper, more accessible fuels with higher sulfur contents.

[59] MGO – marine gas oil – a distillate fuel oil with the sulfur content below 0.1%. Its use is possible after a cheap modification in the engine, but the price of the fuel is high (Lotos Group is the only producer of MG in Poland and one of the few in the Baltic Sea basin).

[60] *Way Forward SECA report*, ESN, November 2013.

[61] *Way Forward SECA report,* ESN, November 2013.

Table 18. SWOT analysis of bunkering from the point of view of Świnoujście LNG terminal operator

Strengths	Weaknesses
– good relationships with Polish ports – coming into force of the so-called Sulfur Directive[61] within the European SECA	– the "first steps" problem: decisions on the model of activity and their potential evolution depending on market development – lack of a clear definition of links in the logistic chain in which Polskie LNG is to participate and the principles of the participation – Polish ports are not located on the main logistic routes of the Baltic Sea
Opportunities	**Threats**
– engagement in the initial stage of market development gives the possibility to obtain "first movers' advantage" – greater use of the terminal's infrastructure – expected development of LNG market in using LNG as a bunkering fuel	– competition with other terminals in the Baltic Sea region – ERO regulatory policy

Source: Original study.

Depending on the analysis center, the estimation of using LNG as a fuel for ships sailing within SECA varies, but by 2025 approx. 10–15% of newly-built vessels dedicated to SECA are going to be LNG-fueled. Regarding the current fleet in terms of ship age and construction, the costs of adjusting, fuel logistics and the possibilities of other solutions, as well as price difference between MGO and LNG, about 1–2% of the ships may be converted. Due to the amount of bunkering fuel sold currently in Polish ports (estimated to be approx. 500 thousand tons), as well as the possibility to supply LNG for bunkering to other ports on the Baltic Sea, there is a potential

[62] In October 1973, the International Convention for the Prevention of Pollution from Ships was adopted. It was modified in 1978 and now is called MARPOL 73/78. MARPOL 73/78 also established special *Emission Control Areas* (ECAs), which have more restrictive standards due to higher sensitivity of the environment in the area or ship traffic. After the coming into force of Annex VI to MARPOL 73/78 in May 2005, new Directive 05/33/EC was adopted to replace Directive 99/32/EC, which introduced the limit of sulfur content of 1.5% for SECA ships and for passenger ships calling at ports in Member States. Furthermore, a limit of sulfur content of 0.1% was set for inland ships and ships stationing at port wharfs. On January 1, 2015, new regulations became valid: the so-called Sulfur Directive entered into force, which obliges all ships within the European SECA to use marine fuels with maximum 0.1% sulfur.

at Polish ports of 60–80 thousand ton LNG per year by 2025. In the case of supply of bunkering fuels, including LNG, to a ship, four models of activity are possible[63]:

1. Bunkering off-shore using a specialist vessel, a so-called bunkering boat (*ship-to-ship*, STS).

2. Bunkering from the shore, using LNG tanker trucks (*truck-to-ship*, TTS).

3. Bunkering from the shore using a terminal (*shore-to-ship via pipeline*, PTS).

4. Replacement of whole fuel tanks (*portable tank transfer*, PTT).

The models involve various costs, possibilities of setting a logistic chain of fuel supply to the customer's vessel, and different flexibility levels in terms of supply of certain volumes of LNG. The choice of the model of supply may also be determined by factors other than volume, such as the size and shape of the harbor, the kind of ships the port serves, the proximity of other ports, and the possibility of providing service to them. In Poland, it is most important at the moment to make concrete decisions and actions[64] connected with measurable investments in a certain model of the functioning of a logistic chain of LNG supply in the bunkering segment: the lack of any decision in this area in a year or two may lead to plans for selling LNG at Polish ports by companies related to the Treasury (which often publish information in the press about bunkering LNG) becoming dematerialized and disappearing because of the activity of competitors from other countries or other (private) entities.

6.1.4. "Tank–vessel" loading

"Tank–vessel" loading is a service that will be performed as part of bunkering LNG and will include the supply of LNG to smaller LNG terminals in other ports (or their close proximity).

The main threat to the attractiveness of this service is that LNG may potentially not be competitive in terms of price, but taking into consideration the long-term development of the LNG market and the use of the LNG terminal in Świnoujście by entities other than PGNiG, including direct producers of LNG, we may assume that development of that service in the long run will adequately meet the demands of customers.

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[63] *Liquefied Natural Gas (LNG) Bunkering Study,* DNV GL, September 2014.

[64] Currently available information for the public is that no final decisions have been made yet as to how investments in infrastructure for ship bunkering should be carried out or who should do it.

Table 19. SWOT analysis of the possibility of offering "tank–vessel" services

Strengths	Weaknesses
– potential development of LNG market in the Baltic Sea region, resulting among others from the Sulphur Directive	– the "first steps" problem: decisions on the model of activity and their potential evolution depending on market development – the lack of a clear definition of links in the logistic chain in which Polskie LNG is to participate and the principles of such participation
Opportunities	Threats
– engagement in the initial stage of market development gives the possibility to obtain "first movers' advantage" – greater use of the terminal's infrastructure – expected development of LNG market in using LNG as a bunkering fuel	– competition with LNG supplied from the Russian Federation

Source: Original study.

From the point of view of Polish entities, be they PLNG or PGNiG, the greatest threat, apart from the lack of specific decisions and actions of the entities, is and will be the competition from suppliers that buy LNG from the Russian Federation. The terminal in Klaipeda will shortly be able to offer the service.

6.1.5. Storage and/or long-term storing of LNG

There are several different types of LNG terminals:

a) Onshore terminal – liquefied natural gas is pumped from tankers to tanks located on the shore, close to the port. LNG is re-gasified in onshore installations and pumped into the gas system.

b) Offshore gravity-based terminal – the terminal and installations for LNG re-gasification are located on an artificial island. LNG is delivered to the terminal, re-gasified, then pumped into the onshore transmission network by submarine gas pipeline.

c) Re-gasification tanker – the re-gasification structure is located on the ship transporting LNG (tanker). After reaching the port of destination, liquefied gas is re-gasified directly on the tanker and pumped into the onshore transmission system by water gas pipeline.

d) Offshore storage and re-gasification terminal – a floating platform or ship with LNG tanks and re-gasification infrastructure. The terminal is permanently or temporarily immobilized at a certain point on the sea, near the

coast. Liquefied natural gas is pumped from tankers to the terminal, where it is re-gasified. Then, natural gas is pumped into the onshore transmission network by a submarine gas pipeline[65]. Tanks located at the terminal (or on the ship where the re-gasification process occurs) can sometimes serve not only as buffer capacities providing reloading and re-gasification services, but also as gas storage facilities.

In several countries, the capacities of LNG storage tanks are used to store mandatory stocks (if the law so provides) or long-term/strategic stocks. In the vast majority of cases, this occurs in countries that have no geological conditions for creating underground gas storage facilities (Japan, South Korea, partly Spain). It is also possible in countries where the speed of development of the LNG market was so high, and the geological and market factors connected with the construction of underground storage facilities so unfavorable in comparison to LNG tanks (Spain), that investors (and state regulations) built gas storage facilities in overground tanks[66]. In Spain, LNG stored in overground tanks which – thanks to adequate highly efficient re-gasification installations had a high capacity for feeding the transmission system despite substantial hourly changes – was the basis of balancing with CCGT installations (in 2010 – 22 GW) the electricity system with a high number of wind power plants (in 2010 – 17 GW)[67]. In other countries, underground storage facilities were used to store mandatory stocks, long-term stocks, strategic stocks, or seasonal stocks when possible.

An LNG terminal that would like to provide storage services would have to properly separate some of its capacity devoted to storage, and appoint an operator of the natural gas storage system for those capacities and for the services provided, subject to the control of Energy Regulatory Office.

Implementing into Polish law *Regulation (EU) No 994/2010 of the European Parliament and of the Council of 20 October 2009 concerning measures to safeguard security of gas supply and repealing Council Directive 2004/67/(EC)*, also including the issue of stocks required for natural gas sold as LNG, would potentially be an opportunity to provide LNG storage service. Currently, Polish law regulates issues connected with mandatory stocks of crude oil and liquid fuels, LPG, coal, and natural gas[68]. In the case of natural gas stocks:

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[65] *Encyklopedia LNG [LNG enyclopedia]*, http://lng.edu.pl/pl/centrum-edukacji/rodzaje-terminali-lng/ (accessed: 02.08.2105).

[66] *LNG vs storage? What solution for Europe?*, Platts' 2nd Annual Developing European Gas Supply Infrastructure, 4 November 2008.

[67] *Interaction between LNG facilities and underground gas storage vs gas demand pattern*, Platts 4th Annual European Gas Storage.

[68] Act of 16 February 2007 on stocks of crude oil, petroleum products and natural gas, the principles of proceeding in circumstances of a threat to the fuel security of the State and

a) it only refers to entities importing natural gas, except for entities importing less than 100 million m^3 a year,

b) it does not refer to entities importing natural gas for their own needs, which allows the establishment of purchase groups made up of many entities, including entities considered by law as so-called protected consumers, and buying gas abroad through a specific entity,

c) natural gas classified as mandatory stock has to be stored in installations that are able to release it to the (transmission or mixed) gas system within 40 days.

These conditions *de facto* exempt the LNG market from the obligation of maintaining mandatory stocks. Even if one of the companies importing LNG exceeds 100 million m^3 of import per year within a few years, it will have to have stocks in the installation connected to the gas system and be allowed to return the mandatory stock of natural gas to the gas system within 40 days. Energy Law[69] defines the gas system in Article 3.23: "gas system or electricity system – the gas or electricity grids and the installations connected to them as well as the installations interacting with the grid". So the gas system includes gas networks etc. Article 3.11 of Energy Law reads: "grids – interconnected and cooperating installations, used for transmission or distribution of fuels or energy, belonging to energy enterprises". This means that companies importing LNG and having re-gasification installations connected to their own gas system (in the vast majority, an island system) will be able to keep some or all mandatory stocks in tanks connected to the systems. However, in most cases, the decision to take up the investment (extra tanks) would be dependent on costs.

It must also be emphasized that although Regulation 994/2010 does not refer to protected consumers as entities that use LNG for transport purposes, which probably results from the negligible size of that market in Europe (LNG was not mentioned, either, in Council Directive 2009/119/EC of 14 September 2009 imposing an obligation on Member States to maintain minimum stocks of crude oil and/or petroleum products[70]), in the face of the growing market for using LNG for transport purposes the situation may change. As it seems, MAE will be one of the first organizations to draw attention to this and try to introduce some standards concerning the issue.

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disruption on the petroleum market (hereinafter: the Stock Act), Journal of Laws of 2007, no. 52, item 343.

[69] Energy Law Act of 10 April 1997 (Journal of Laws U. of 1997, no. 54 item 348.

[70] OJ EU L 265 of 09.10.2009, p. 9.

Table 20. Amount of mandatory stock created by an entity selling gas from an LNG tank with a geometric capacity of 60 m³

volume of natural gas sold	2,000,000	Nm³
volume of LNG sold	3,333	m³
density of LNG	600	Nm³ /m³LNG
mean daily sales	9.1	thousand Nm³
sales at the peak of demand	18.3	thousand Nm³
mandatory stock for:		
7 days	63.9	m³ LNG
10 days	91.3	m³ LNG
14 days	127.9	m³ LNG
30 days	274.0	m³ LNG

Source: Original study.

Table 21. Amount of mandatory stock depending on the adopted solutions concerning the number of days for which the stock is created and the volume of gas sales to protected consumers

thousand m³ of consumption	obligatory stock in thousand m³			
	7 days	10 days	14 days	30 days
200	3.84	5.48	7.67	16.44
400	7.67	10.96	15.34	32.88
600	11.51	16.44	23.01	49.32
800	15.34	21.92	30.68	65.75
1,000	19.18	27.40	38.36	82.19
1,500	28.77	41.10	57.53	123.29

Source: Original study.

Table 22. Active and planned storage capacity of underground natural gas storage facilities in Poland

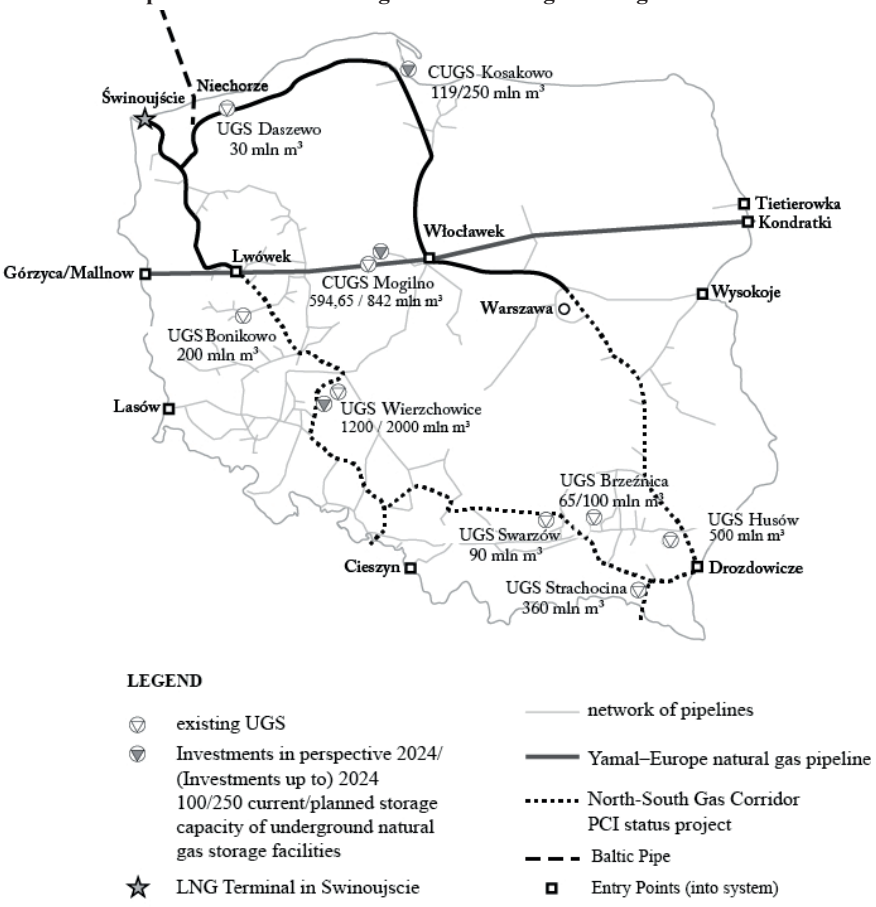
	Active capacity [mln m³]	Active capacity [mln m³] target	Kind of storage facility	time of completion of construction/ extension
Brzeźnica	65	100	depleted	2015
Husów	350	500	deposit	2014
Kosakowo	51.2	250	depleted	2021
Mogilno	407.9	800	deposit	2027
Strachocina	330	360	salt cavern	2014
Swarzów	90	90	salt cavern	—
Wierzchowice	575	1,200	depleted deposit depleted deposit depleted deposit	2014

Source: Own study based on information from PGNiG[71].

[71] *PGNiG*, http://www.pgnig.pl/pgnig/segmenty-dzialalnosci/obrot-i-magazynowanie/magazynowanie (accessed: 18.07.2015).

Short-term balancing of trading portfolios for entities trading in natural gas trade in Poland could be an additional opportunity related to the storage of certain amounts of LNG.

Map 6: Location of underground natural gas storage facilities



Source: M. Ruszel, *Bezpieczeństwo energetyczne Polski. Wymiar teoretyczny i praktyczny [Energy security of Poland: theoretical and practical aspects]*, Wydawnictwo Rambler, Warsaw 2014, p. 125.

In the other cases, LNG storage in tanks at the LNG terminal will provide direct competition for underground gas storage facilities. Currently, storage capacities in Poland are owned practically 100% by GK PGNiG S.A. More facilities are to be created by the transmission pipelines operator

Gaz-System and GK PKN Orlen S.A.[72] The underground gas storage facilities planned by Gaz-System S.A. and GK PKN are entered on the *List of projects strategic for energy infrastructure in the Operational Programme Infrastructure and Environment 2014–2020* (which is a pipeline project for the energy sector within the Operational Programme Infrastructure and Environment 2014–2020)[73].

Table 23. Underground gas storage facilities planned by Gaz-System and PKN Orlen

Investor	Investment	Kind of storage facility	Estimated target capacity (million m^3)	Time of completion (leaching of salt caverns)
OGP Gaz-System S.A.	Construction of an underground cavern natural gas storage facility in Damasławek salt deposit	Cavern storage facility	1,600	2020-2046
GK PKN Orlen	Construction of an underground cavern natural gas storage facility in Damasławek salt deposit	Cavern storage facility	800	

Source: Original study on the basis of data from the Ministry of Economy, PKN Orlen and Gaz-System.

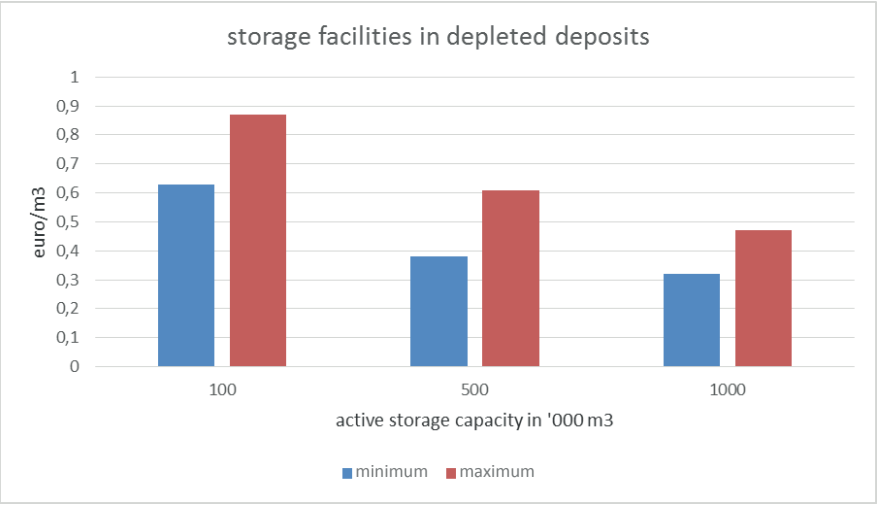
It is worth remembering that as LNG is stored in a storage facility installation, natural re-gasification *(boil-off gas, BoG)* occurs due to the increased temperature of LNG. BoG depends much on tank capacity; for large tanks, it is between 0.02 and 0.05% a day. If the operator of a terminal decides to engage in storage activity, the operator should develop and adopt appropriate procedures connected with settling BoG with customers. Storing gas in LNG tanks is associated with high investment and operating costs in com-

[72] Full minutes of the session of the Treasury Committee (no. 136), http://orka.sejm.gov.pl/zapisy7.nsf/0/A59432813C90F0C2C1257E1400445B13/$File/0439807.pdf (accessed: 24.07.2015).

[73] List of projects strategic for energy infrastructure in the Operational Programme Infrastructure and Environment 2014–2020, http://www.mg.gov.pl/files/upload/22601/Lista%20Projektów%20Strategicznych.pdf (accessed: 24.07.2015).

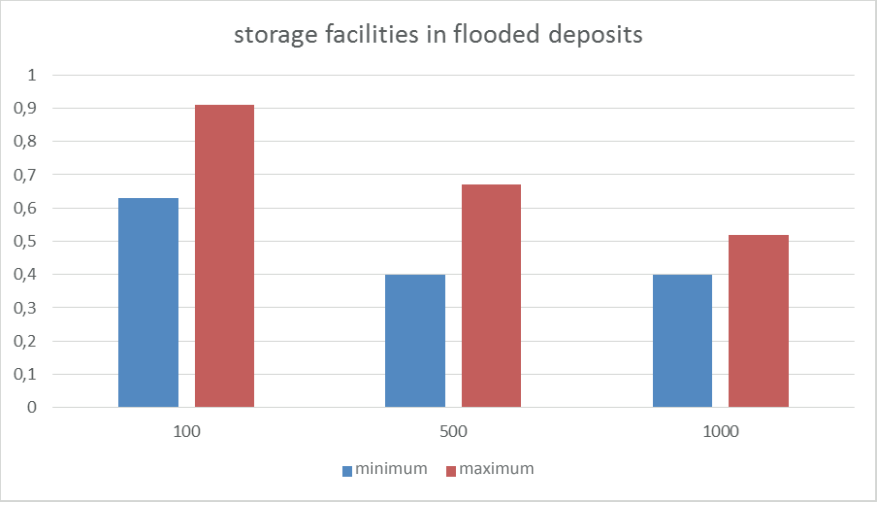
parison to other kinds of natural gas storage facilities, as presented in the following charts.

Chart 11. Storage facilities in depleted deposits



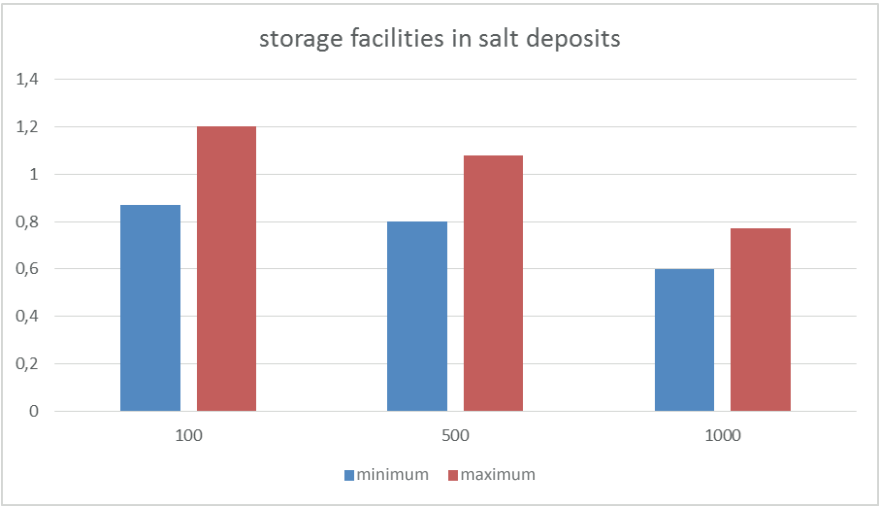
Source: Original study based on *Study on Natural Gas Storage in the EU*, Ramboll, 2008.

Chart 12. Storage facilities in flooded deposits



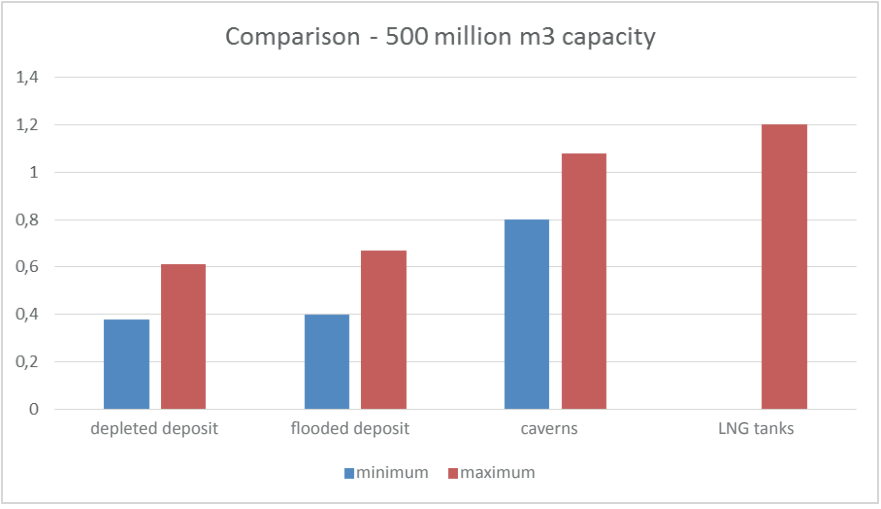
Source: Original study based on *Study on Natural Gas Storage...* op. cit.

Chart 13. Storage facilities in salt deposits



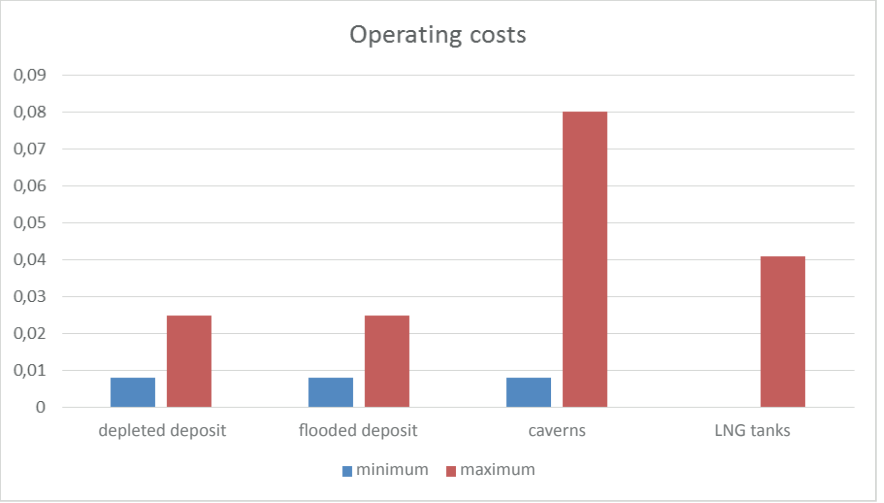
Source: Original study based on *Study on Natural Gas Storage...* op. cit.

Chart 14. Comparison of capacities of gas storage facilities



Source: Original study based on *Study on Natural Gas Storage...* op. cit.

Chart 15. Operating costs of gas storage facilities



Source: Original study based on *Study on Natural Gas Storage...* op. cit.

Assuming that storing gas in LNG tanks is an alternative to underground storage facilities, taking into account the costs of such storage and the plans for construction and extension of underground gas storage facilities by entities other than Polskie LNG, as well as the fact of amortizing[74] the assets of underground gas storage facilities belonging to GK PGNiG S.A., it must be said that this form of storage will not be more advantageous than other available storage possibilities in the vast majority of business cases. But the lack of competitiveness or the lack of demand for long-term storage of LNG in terminal tanks does not mean that there is no possibility of more efficient utilization. One such possibility (e.g. in the Zeebrugge terminal in Belgium) is long-term storage of LNG. The scope of the service, i.e. the number of days for which LNG can be stored in terminal tanks exceeding the standard rate for reloading and re-gasification, will depend on the level of filling the terminal. If the re-gasification capacity of the terminal constructed by Polskie LNG S.A. is used up to 100%, only 2-3 days of storage would be possible. The lower the utilization of the LNG terminal in Świnoujście, the higher the possibility of long-term storage of LNG. Besides, the conditions of the service should not only involve the number of days for which LNG can be stored over the standard time, but also the amount to be stored, because the

[74] It means the prices/fees for storage services may be reduced.

storage of e.g., 120 thousand m^3 LNG for a month is not the same as storing 20 thousand m^3 LNG.

To conclude, it must be said that using available assets, after the 1st stage of construction it will be possible to offer natural gas storage service, but whether the offer will meet demand depends on its form and further development of the natural gas market in Poland.

Table 24. SWOT analysis of Świnoujście LNG terminal offering storage services

Strengths	Weaknesses
– high performance – impossibility of release of natural gas to the gas system with emptying the storage facility	– high investment costs – high operating costs – relatively little capacity in comparison with underground storage facilities – the need to establish the operator of the storage system – the need to separate for accounting purposes the capacity devoted to storage
Opportunities	Threats
– short-term balancing of gas sellers' portfolios – introducing mandatory stocks of gas in the LNG segment	– high supply of storage capacity – lower charges for natural gas storage – regulatory policy

Source: Original study.

6.1.6. Supply of useful heat

There are several types of LNG re-gasification[75]. More than half of the devices applied nowadays in re-gasification use so-called ORV (*Open Rack Vaporizers*) to heat up LNG, with water as the heat carrier. In the case of terminals located in areas with a colder climate it is necessary to use methods based on heating the heat carrier – SCV (*Submerged Combustion Vaporizer*). CHP–SCV (*Combined Heat and Power Unit–Submerged Combustion Vaporizers*) are exchangers for LNG re-gasification in combination with cogeneration energy production installations. STV (*Shell and Tube Vaporizers*), where heat exchangers are especially designed installations made up of case and tube sets, using heat from the exhaust system of gas turbines. AAV (*Ambient Air Vaporizers*) are systems of exchangers that use heat to vaporize LNG from ambient air. AAV–HTF *Ambient Air*

[75] M. Łaciak, S. Nagy, J. Szpytko, *Problemy techniczne i technologiczne związane z rozładunkiem LNG [Technical and technological problems connected with the unloading of LNG]*, "Nafta – Gaz", July 2012.

Vaporizer–Heat Transfer Fluid) are AAV exchangers using the indirect method of heat transfer.

Supplies of useful heat and electrical energy are connected with the construction of a thermal power station based on natural gas at the LNG terminal. Depending on the adopted variant, it could be either cogeneration gas engines or a heat recovery gas turbine. Most of the heat would feed the module(s) used for re-gasification of LNG, and some of it could go to the part of Świnoujście near the terminal. The subject is connected with several problems and dilemmas that must be solved before implementation. For example, what should power the heat and power plant (basically, the highest efficiency is achieved at continuous work but even the future use of the terminal is unknown) or what would be its priority: hot water or the production of electricity? The flow of hot water can be managed by building a so-called heat battery, i.e. a properly insulated tank with adequate capacity, in which hot water would be kept and used whenever the plant experienced a stoppage. In addition, the tank would be a good stabilizer of the temperature of hot water flow to external consumers.

Table 25. SWOT analysis of heat energy supplies from a cogeneration system that could be built at the LNG terminal in Świnoujście

Strengths	Weaknesses
– more efficient use of natural gas devoted to the process of re-gasification – lower emission of harmful substances to the environment	– technological problems even in already completed re-gasification modules – problem with precise determination of the capacity of the installation allowing it to work as efficiently as possible – no data on the level of exploitation of the terminal in the future – no thermal power station in the construction permit – the need to go over the whole investment cycle again, including the potential protests from residents – ERO regulatory policy
Opportunities	Threats
– maintaining support for highly-efficient cogeneration after 2018	– potential low level of exploitation of the terminal, and thus the installation of the cogeneration

Source: Original study.

6.1.7. Supply of cold

The LNG terminal could provide a supply of cold for entities located in close proximity to the terminal, such as e.g. fish processing companies, cold stores, or ice producers. At the moment, there are no such entities, but the strategy of the Świnoujście port includes service plans for companies for which cold is one of the basic factors of operation.

Table 26. SWOT analysis of cold supply services

Strengths	Weaknesses
– large amounts of cold available at the terminal – according to the operation manual, the cold belongs to the terminal (not the customer who has brought it to the terminal); hence, as a carrier, it generates no costs for the terminal	– the problem of logistics of supply of cold for the customer – the need to maintain gas pipelines in cryogenic conditions – the need to find a big consumer of cold
Opportunities	**Threats**
– the development of the port in Świnoujście and economic activity connected with the port and fishing / fish processing industry	– social and environmental – protests of residents

Source: Original study.

6.1.8. Supply of electricity

The production of electricity could take place in the terminal or the heat and power plant. If the power plant, the water used in it would have to be cooled anyway[76], which would be associated with the use of cold and re-gasification. However, with regard to the efficiency of the production process, a functioning system based on cogeneration and the price of electrical energy at the Power Exchange, the supplies of electricity would be connected with the construction of a heat and power plant at the terminal, as partly described in the section on heat supplies. In the close proximity of the terminal, there is 110 kV electrical line that can receive 50 MW of electrical energy. Most of the risks connected with construction of the heat and power plant were described in the section on heat supplies.

[76] In this case, a heat recovery power plant would have to be built.

Table 27. SWOT analysis of cogenerated electricity production at the LNG terminal

Strengths	Weaknesses
– proximity of 110 kV lines – independence of an external source of electricity	– relatively low, highly cyclical electricity consumption at the terminal – technological problems even in already completed re-gasification modules – problem with precise determination of the capacity of the installation allowing it to work as efficiently as possible – no data on the level of exploitation of the terminal in the future – no thermal power station in the construction permit – the need to go over the whole investment cycle again, including potential protests from residents
Opportunities	Threats
– maintaining a system of support for cogeneration after 2018 – possibility of developing direct supplies to the developing port in Świnoujście – the extension of the terminal and an increase in demand for energy for own purposes	– regulatory policy of the state in terms of support for cogeneration – high prices of natural gas and relatively low prices of electricity

Source: Original study.

Conclusion

Over the last fifty years, the natural gas market has become globalized thanks to two coexisting channels of gas distribution in international trade: gas pipelines and liquefied gas distribution. The increase in the scale of international trade in natural gas resulted from increased demand for energy resources connected with economic growth, and from the increasing availability of natural gas on international markets. Development of the LNG industry has made it possible to obtain natural gas in countries with which the importing countries have no gas connections. Recently, changes have occurred on the energy market which are mostly positive from the point of view of consumers in the European Union. The growing competition on the side of LNG demand and transport units is transforming the market from one where producers dominate into one where the position of both parties to the contract is more or less equal. In the context of member states pursuing diversification of natural gas supplies, the changes on the market should be perceived as something positive. LNG allows importers to introduce innovative technologies, and consumers to develop new consumption behaviors based on liquefied gas. The developing LNG industry first implemented the real idea of a global natural gas market. Over the last fifty years, it has evolved to become a significant section of the market, on which more than 30% of natural gas trade takes place. Globally, changes have occurred in each link of the supply chain. New technologies of looking for natural gas have been developed, which has reduced the unit cost of extraction, and there has been large investment in liquefaction capacities, enabling the export of resources. Investorment has improved the technology of transport, especially in recent years causing a significant increase in the fleet of modern tankers. Consumers are adjusting their re-gasification technologies so as to optimally use the existing technology, and have adjusted them to the climate of terminal locations. All this activity and the growing demand for natural gas have led to the creation of a competitive market.

Awareness of the importance of links in the supply chain makes it possible to develop procurement strategies and to derive real benefits either from participation in creating them, or by establishing micro-scale strategies for regional or national needs. Due to market dynamics, however, we need to constantly follow the changes, because – like on every global market – changes in one of the links may trigger chain reactions, affecting the

business environment in sectors connected with other links. Ultimately, these will also affect the offer. Despite the threats related to globalization, the market offers many opportunities as well. First of all, the market has opened up, increasing the energy security of countries importing hydrocarbons. Second, innovations in LNG technologies mean more and more new applications for the simplest hydrocarbon. Around the LNG market, sectors supporting the supply chain will develop, as well as new subsectors associated with the supply of natural gas from a new source, whose liquefied form's physical properties facilitate its transportation.

For EU member states, access to the LNG market lowers the risk connected with disrupting the continuity of natural gas supply, and thus increases the energy security of the country and improves the position of particular member states and the whole European Union in negotiations with suppliers. These advantages of LNG have made it play a more and more important role in the energy policy of the European Union and its member states, including Poland. That is why political and regulatory measures are being taken to ensure broader application of the fuel. The EU is going to expand the energy infrastructure that allows member states direct or indirect (via neighboring countries) access to the global LNG market. Important for this will be better regional cooperation and the improvement of capacity of interconnectors. EU strategic documents, market forecasts, and investment plans show that the liquefied gas market will constantly grow, and LNG will remain one of the main sources of diversification of natural gas supplies to the EU. We expect that as new investment in LNG terminals is carried out and more natural gas sources are discovered in the world, the competition will grow, between both the suppliers of liquefied gas and the exporters of natural gas through pipelines and LNG terminals. From the EU perspective, the growing competition between exporters will be beneficial for the development of the EU gas market and the improved energy security of Europe.

Although there is no reference in the primary law of the European Union to LNG market regulation, the framework solutions included there provide a model for the current market. The new EU policy on energy introduced in the Lisbon Treaty includes the construction of connections between countries, and does not exclude connections within the chain of supply of LNG. The introduced legal solutions integrating the wholesale market of natural gas and unifying the technological principles of its functioning offer the opportunity to build trade strategies based on reduced risk connected with the existence of different regulatory determinants. The solutions of national laws allow the use of LNG; special regulations for construction of an LNG terminal, despite a negative impact on the legal system, have facilitated the investment process. It is also emphasized that LNG is going to become an

alternative to fuels used nowadays in road, sea, and air transport. However, it is necessary to further develop energy infrastructure to allow improved efficiency of the supply chain, which will ensure the possibility of refueling vehicles, bunkering ships, and using LNG for other purposes.

The economic conditions of the LNG market have been changing and will continue to change dynamically. This is directly influenced by geological discoveries of conventional deposits in regions that have not extracted gas so far, the increased capacities of previous producers, and the development of mass production of unconventional gas in North America. These processes have led to constant, dynamic growth in LNG production. In 2014, LNG production exceeded 330 bcm, while 7 years before, it was 230 bcm. Another increase in production is expected by the end of this decade, at least by 1/4. At the end of 2019, global LNG sales should reach at least 450 bcm. Dynamic increase in production is forecast for the next decade, when large-scale export from Australia, Canada, the USA, Africa, and elsewhere is expected. Recently, demand for LNG has changed worldwide, and markets have stratified. In Asia, demand has increased as a result of constant economic development and the accident at the Fukushima nuclear power plant (in 2011), which caused greater demand for gas as nuclear energy in the country was disabled. As a result of those processes and a lack of sufficient domestic extraction and few import pipelines, the prices of LNG in Asia-Pacific are higher than anywhere in the world. Forecasts indicate that gas prices will remain higher there at least until the end of the decade. In European countries, a rapid reduction in LNG purchase has occurred recently. The market has shrunk by several dozen percent and at the moment is approx. 45 bcm a year, which means that only ¼ of re-gasification terminals capacity in EU member states is currently utilized. In Western Europe, LNG has become less competitive than the cheaper and more and more flexibly sold gas from the North Sea region and Northern Africa. The level of LNG import in Western Europe is likely to be partially restored soon. These seemingly unfavorable conditions have not blocked new investments in re-gasification terminals in European Union countries. This is probably connected with the anticipated increase in medium-term supply of liquefied gas and the transformation of the market so as to ensure greater fluency, facilitating the conclusion of shorter contracts and purchases on the spot market. Nowadays, we can see the process of market transformation, i.e. departure from long-term contracts in favor of spot supplies, where purchase price is of key importance.

The LNG terminal in Świnoujście is extremely valuable from the point of view of regional gas market. It is a new point of entry to the system, enabling supplies from new producers through transmission routes other than before. This naturally improves the energy security of the country and its

resistance to unexpected disturbances in supplies. The LNG terminal is ushering in a new quality related to the possibility of using the global market of suppliers. It is possible that LNG purchased on short-term and spot markets will be competitive or have a similar price to gas delivered via gas pipelines from Russia on the basis of a long-term contract. It is also possible that after the commissioning of the LNG terminal in Świnoujście the prices of gas delivered via pipelines will drop as a result of possible competition. In the medium-term perspective, the economic efficiency of the national LNG terminal may increase. Potential beginning of LNG supplies e.g. from the United States, Africa or Canada may ensure the supply of gas at prices lower than via pipelines. Such import will be possible at a greater scale in the next decade. Before, due to the expected low scale of LNG production in the USA, supplies would only have been possible with greater political support. That is why the LNG terminal in Świnoujście is vital for the national market, and its role on the regional market may grow very much in the future. Potential sale of gas to markets such as the Visegrad Group, the Energy Community, or the Baltic Sea region will be more effective as the transmission network expands and market instruments are built in the region.

We should also remember the additional services that have an impact on the significance of the Świnoujście terminal. Apart from the basic LNG re-gasification service, it is recommended to develop especially loading services for tanker trucks or bunkering ships. Depending on the situation on the Polish and international natural gas markets, it will then be beneficial to develop "tank-vessel" loading and extended storage services. The production and supply of heat and electricity seem to be an attractive form of terminal revenue diversification (and cost reduction), but environmental, construction, and contractual issues (guarantees for works currently being carried out) may make it difficult. It seems that the most risky investment would be the investment in and development of the service for loading rail tankers, whereas the supplies of negative heat (cold) are a very interesting option, though difficult to define in terms of costs and time.

The Authors

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“Global LNG Market” is a thorough and comprehensive scientific publication addressing all contemporary aspects of dynamically developing liquefied natural gas market. When analysing global trends, the Authors not only present the current impact of LNG on energy security and the competitiveness of EU economy, but they also try to forecast the potential changes in the market, mostly resulting from the emergence of new sources of natural gas in the world. The multidimensional character of this publication lies in the in-depth analysis of legal, regulatory and economic determinants of the industrial and commercial potential of the newly constructed Polish LNG terminal in Świnoujście. This is the first publication addressing the most relevant aspects of contemporary LNG market in Polish scientific literature.

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