ARTICLES

CENTRAL EUROPEAN REVIEW OF ECONOMICS & FINANCE
Vol. 44. No 3 (2023) pp. 79-98
DOI https://doi.org/10.24136/ceref.2023.015

Agnieszka Pach-Gurgul[1]

DEVELOPMENT OF THE LNG MARKET IN THE EUROPEAN UNION IN THE CONTEXT OF WAR RUSSIA-UKRAINE

Abstract
According to the latest data from the International Energy Agency, global LNG trade increased by almost 6% year-on-year between January and August 2022. It was dominated by rising demand for the commodity in the European Union. This was driven by sharp cuts in linear gas supplies from Russia, which are linked to the EU's stance of abandoning Russian supplies due to Russia's war with Ukraine, and the subsequent imposition of sanctions by the European Union on Russia. In January-August 2022 alone, LNG imports into the EU increased by as much as 65% (43 bcm) compared to the same period in 2021. Such a significant increase in the supply of LNG to European countries was also made possible by a decline in demand for LNG in the Asia-Pacific region, due to the mild winter, high price levels, and disruptions related to Covid-19 and the aftermath of lockdowns in China. The cut-off of gas supplies from Russia has shown that the LNG market in the EU can play an important role in both the region's energy security and energy transition. In fact, the European Commission treats gas as a blue fuel, much less carbon-intensive than other conventional energy sources such as coal or oil. An additional advantage

---

[1] PhD, Assistant Professor at the Department of International Economics at Cracow University of Economics, the publication was financed from the resources grated to the Faculty of Economics and International Relations of the University of Economics in Krakow as part of the subsidy for the maintenance of the research potential.
* The publication was financed from the subsidy granted to the Cracow University of Economics – Project nr 075/EEG/2022/POT.

of LNG is the possibility to transport this fuel from various locations, rapid change of supply directions, and the more extensive possibilities for its storage. For an EU struggling for a stable supply of raw material, pursuing the Green Deal and carrying out an energy transition, this is an option that could become a strategic element in the long term. The research objective of this article is to investigate and analyze how the share of LNG in the EU's energy mix has changed and in what direction it is affecting EU energy security after Russia's aggression in Ukraine.

JEL Classification Code: Q41, Q34, Q32, Q47

Keywords: energy security, gas import, LNG, Russia-Ukraine War.

1. Introduction

Energy security is a multifactorial issue which keeps constantly evolving: it refers to either a unit, state, process or phenomenon. A debate about this problem concerns not only the question of energy security as such (both subjectively and objectively treated), but also its measurements, background and determinants (Pach-Gurgul, 2015).The literature of the subject presents a number of definitions, whilst the term keeps expanding, including new aspects added as a result of many national and international factors. Following the definition of Yergin (2006), energy security is defined as "ensuring adequate energy suppliers at affordable and reasonable prices". Månsson (et al. 2014) in turn, defines energy security as "the availability of energy at any time, in various forms, in sufficient quantity and at a reasonable price and/or an affordable price". Energy security can also be defined as "the availability of adequate energy at an affordable and reliable price, necessary both from the technological point of view and also from the perspectives of human security" (Wang et al., 2018; Sovacool, 2013, Augutis et al., 2012). Many contemporary researchers of the security emphasize the interdisciplinary approach to energy security, expanding the limits of the area of energy (Månsson, 2014; Cipollaro and Lomonaco, 2016; Löschel, Moslener and Rübbelke, 2010).

With time, also for the EU member states, energy security and its multiple aspects have become the main challenge, though treated in diverse ways. Within the last 30 years, there have emerged a number of key threats and factors which shaped the form of energy security, prioritizing it within the European Union. As Van de Graaf & Colgan, J. (2017), and also Goldthau & Boersma, (2014) observe, an important role in this process was played by gas cut-offs made by Russia in winter 2005/2006, and also in winter 2009 and in June 2010 which resulted in the withholding od the gas supplies for specific EU member states, leading to huge economic costs. Additionally, the growth of the significance of the energy security was also influenced by the following factors:

- Fluctuation of the oil prices on world markets;
- The execution of the particular interests of specific states, such as the Nord Stream project which caused many concerns on the part of some EU member states, i.e. Poland and some Baltic countries;
- The Fukushima nuclear accident in 2011, which resulted in the abandonment of the nuclear energy development and the extinguishment of the nuclear reactors in some EU counties, such as Germany;
- The impact of the Covid-19 pandemic on the global market of energy sources.

Currently, energy security belongs to the competencies shared within the EU, pursuant to article 194 of the Treaty on the Functioning of the European Union (TFEU), which provides the legal grounds for the EU energy policy. This means that there is no obvious legal obstacles for strengthening energy security on the EU level (Consolidated version of the Treaty on the Functioning of the European Union). However, the same article of the Treaty stipulates also that the member states are responsible for their energy baskets and the general structure of the energy supply. Thus, the co-ordination of the EU energy systems depends, to some degree, on the political choices of specific EU member states. Moreover, the member states play the main role in financing the share of renewable energy in their energy mixes and in increasing this share, for example by market incentives. These countries take also decisions about creating energy connections with other countries. The procedures of giving permissions for renewable sources of energy, even if facilitated thanks to the EU legislation (for example with in the REPowerEU and solar energy strategy), require also the participation of the national and local levels in order to guarantee measurable results.

The research objective of this article is to investigate and analyze how the share of LNG in the EU's energy mix has changed and in what direction it is affecting EU energy security after Russia's aggression in Ukraine. Diverse research methods were used to achieve the research objective of this article, including a critical review of the literature on the LNG market and EU energy security and an analysis of source material including reports from independent institutions, documents provided by EU institutions and selected companies.

2. A new dimension of energy security in EU in the context of Russia-Ukraine war

In the recent years, the significance of energy security within the EU policy was greatly affected by the process of energy transformation resulting from the implementation of the sustainable development goals, and also the execution of the Paris Agreement (Esperanza Mata Pérez et al., 2019, Tagliapietra et.al, 2019). The European Union prioritized Europe's transformation into a zero-emission continent by 2050, which also means departing from carbon intensive conventional fuels and conversion to renewable sources of energy and other, alternative low-emission energy sources. As a consequence, energy security was strongly connected with the climatic policy. From today's perspective, it can be stated that perhaps the security of the supply of the energy resources and its diversification was then pushed to the background.

Currently, after Russia's aggression in Ukraine and the resulting energy crisis, energy security understood, first of all, from the perspective of reliable supplies of conventional fuels, such as crude oil, gas or coal, were placed again on the priority place on the EU agenda. This is the outcome of the fact that EU's energy import dependency rate in 2021 was 55.5%, making the European Union the largest net energy importer of the worldwide. In 2021, Russia was the largest supplier of energy to EU, providing 45% coal supplies, 36% gas supplies and 25% crude oil supplies (cf. Fig. 1).

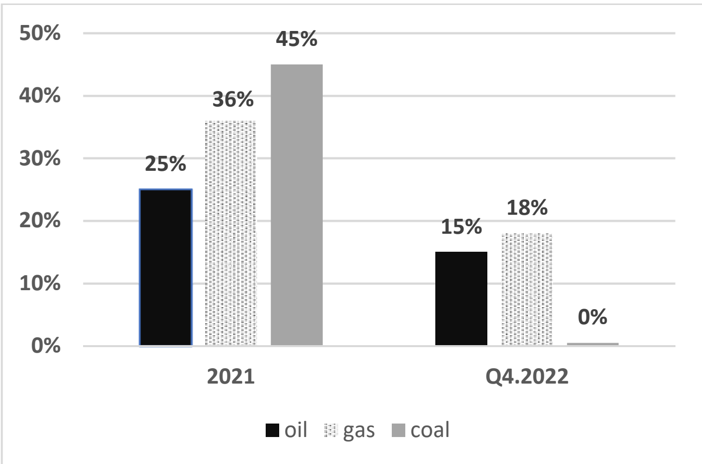

Figure 1. EU's import of Russian energy sources in 2021 and in Q4.2022
Source: the Author's own elaboration on the basis of Future Shocks 2023: Securing energy supply in Europe, https://epthinktank.eu/2023/08/10/future-shocks-2023-securing-energy-supply-in-europe [Access: 20.11.2023]

Within 2022, the situation changed significantly, together with a few rounds of the sanctions imposed in the Russian energy products, political initiatives of the EU aiming to cut off from the Russian energy (e.g. REPowerEU) and the restrictions in gas transmission and setting prices, imposed by Russia.

The most recent data available show that in the third quarter of 2022, EU did not import coal any more, but only 18% of its gas and 15% of crude oil from Russia. However, in spite of all these limitations on the import of the Russian energy resources and the decrease of the energy dependency from Russia, energy security has remained a longterm challenge for the EU, given its high total energy dependency. Moreover, energy crisis resulted not only in the problems with the supplies, but also influenced the price increase which translated into the rise of inflation in the EU countries, which, in turn, affected many household and company budgets. The concern of the availability of resources and their price, in some way, has created a pressure on the increase of self-sufficiency which resulted in reopening of coal mines, in such EU countries as France or Germany in order to survive the winter of 2022/2023, which unfortunately, contradicts the costly energy transformation which has been undertaken.

The impact of war on the energy situation of the EU was the most serious in the case of gas. In 2022, thanks to diverse actions undertaken, the EU managed to avoid disruptions and gas shortages during the winter. Yet the EU is still facing the challenge of intensifying its efforts during the transition from a short-term crisis management to solving the longer difficulty in guaranteeing energy security, including the reliable gas supply and strengthening its strategic autonomy in the energy field. The resolution from March 2022 on Russian aggression of Ukraine, contained an appeal to decrease the EU energy dependency, in particular from Russian gas, crude oil and coal, by means of the diversification of energy sources, development of LNG terminals and supply routes, separation of gas storage facilities, increase of energy efficiency and accelerating the transition to clean energy. Moreover, the EU undertook a number of other actions and issued many documents regulating its standpoint towards Russian aggression, in the context of the threats for reliable supplies of energy resources. These strategies and decisions have been described in the table below:

Table1. The main documents containing actions concerning energy security undertaken by the EU in the context of the Russian aggression in Ukraine

Document	The document essence
European Parliament resolution of 7 April 2022 on the conclusions of the European Council meeting of 24-25 March 2022, including the latest developments of the war against Ukraine and the EU sanctions against Russia and their implementation (2022/2560(RSP))	The European Parliament called for the establishment of common strategic energy reserves and energy purchasing mechanisms at EU level to increase energy security and reduce external energy dependency and price volatility. It also called for a full embargo on Russian energy imports.
European Parliament resolution of 19 May 2022 on the social and economic consequences for the EU of the Russian war in Ukraine – reinforcing the EU's capacity to act (2022/2653(RSP))	Parliament stressed the importance of ensuring energy sovereignty and independence from Russian supplies and more strategic autonomy and energy security, by upgrading and ensuring major investment in the EU's energy infrastructure, including interconnections and cross-border infrastructure for renewable energy production, and energy efficiency.
European Commission, Brussels, 18.5.2022, COM(2022) 230 final Communication From The Commission To The European Parliament, The European Council, The Council, The European Economic and Social Committee And The Committee of the Regions REPowerEU Plan{SWD(2022) 230 final}.	Parliament highlighted the role of investments in renewable energy, energy efficiency and the necessary infrastructure – including targeted, well-defined cross-border projects with investments through NextGenerationEU and REPowerEU – in helping the EU achieve energy sovereignty, open strategic autonomy and energy security.
Regulation (EU) 2022/1032 of the European Parliament and of the Council of 29 June 2022 amending Regulations (EU) 2017/1938 and (EC) No 715/2009 with regard to gas storage (Text with EEA relevance).	In terms of boosting gas storage in response to limited supply, Regulation (EU) 2022/1032 of June 2022 on gas storage set a binding target of 80 % of EU storage capacity to be filled in by 1 November 2022, with a 90 % target set for subsequent years. The regulation was swiftly implemented and storage facilities reached a filling rate of 80 % as early as September and of 90 % as early as October 2022. The EU exited the winter season with record high storage levels of 57 % at the end of April 2023, while the current filling rate (May 2023) stands at 68 %, according to the latest data.

Source: The Author's own elaboration on the basis of Future Shocks 2023: Securing energy supply in Europe, https://epthinktank.eu/2023/08/10/future-shocks-2023-securing-energy-supply-in-europe [Access: 20.11.2023]

At the beginning of 2023, the EU undertook a number of action with an aim to decrease its dependency on Russian energy, among others by means of the diversification of energy supplies, stocking the gas storage facilities, promoting joint purchases of gas, limiting the energy demand

and promoting energy saving, increase of energy efficiency and also supporting the use of renewable sources of energy.

Both for the EU countries and the LNG suppliers, this was a clear message that now this type of fuel would be necessary as an alternative to the Russian gas supplies and that the development of the EU infrastructure making it possible to accept such supplies is necessary, requires.

3. LNG as clean conventional fuel – the process of its obtaining

Liquefied Natural Gas (LNG) is the cleanest fossil fuel. It is obtained as a result of the purification from contaminants and the change from liquid to gas under the influence of very low temperature of about -161°C. Thanks to its purification, as much as 95% of LNG is composed of methane. One cubic meter of liquefied natural gas is about 600 cubic meters of natural gas, which is especially beneficial from the point of view of profitability of transport and storage. When an LNG transport reaches its destination, it is then *re-gasified,* i.e. transferred into gas by means of heating the liquid. The purification makes gas combustion is less harmful because fewer harmful substances are emitted to the atmosphere. As LNG is natural gas in a fluid form, its physical and chemical properties will be similar to these of average natural gas.

In the context of Russia-Ukraine war, it may be surprising why Europe did not rely on the development of the LNG infrastructure and its supplies much earlier, making it a reliable alterative for the fuels coming from the Russian market? It seems that there were many causes for Europe's such a slow decision to convert to LNG as an alternative for the Russian gas with the leading one being the high cost of the entire process of LNG obtaining and processing, which results in the fact that today's commodity exchanges show significant price differences between the world price for natural gas and the price of LNG. This specific process of obtaining LNG which is called the *LNG life-cycle* in its final version is simply very costly and consists of four stages: obtaining, liquefying, transport and regassification.

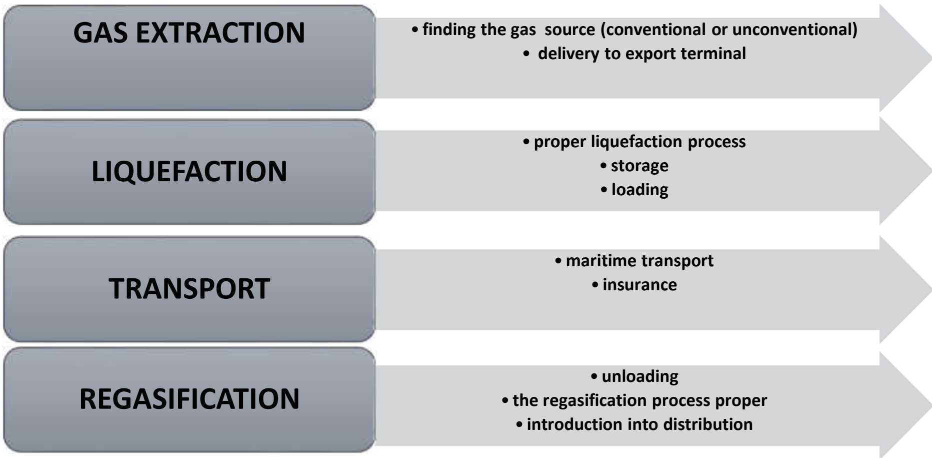

Figure 2. Life cycle of LNG

Source: the Author's own elaboration on the basis of Maxwell D., Zhu Z. Natural gas prices, LNG transport costs, and the dynamics of LNG imports Energy Economics,Volume 33, Issue 2, March 2011, Pages 217-226

The process of obtaining natural gas and its transformation into LNG is very complex and undergoes continual modernizations and modifications. There are many techniques and methods which require the use of specialist equipment, protection measures and extensive knowledge.

The first link consists in obtaining LNG. The share of this component in the total costs depends on a number of factors, such as type of deposit from which the raw material is extracted, the distances from the terminals and also the costs of construction of production and transmission infrastructure. This link of the process makes up approximately 20% of total costs. There are either onshore or offshore deposits. Natural gas is extracted usually with vertical wells drilled in the earth's crust and there are various stimulation methods used to increase the flow of natural gas in the well (Brunner, 2013). One of them is hydraulic fracturing/fracking, which consists in pumping a mixture of water, sand and chemicals into the well under high pressure. This allows the formation or enlargement of rock fractures through which the gas travels. The opponents of this method point out that it requires significant amounts of water, plus dangerous and highly toxic wastewater is produced which might pollute the underwater sources (Jackson et al., 2013).

The next stage involves the purification of natural gas from carbon dioxide, hydrogen sulfide and steam. The compounds of sulfur and carbon dioxide must be removed as in the presence of water they have a corrosive effect on steel from which the pipeline is constructed (Roman-White et al., 2021). Moreover, hydrogen sulfide is highly toxic. After purification, natural gas is liquified. Nowadays there are there main methods of liquefying natural gas. They differ from each other with respect to the installation scale and energy consumption.These methods comprise (Brunner, 2013):

- Classical cascade cycle,
- Cascade cycle with mixed coolant,
- expansion cycle with turboexpander.

The classic cascade cycle involves a large-scale installation, yet the procedure itself is not very energy-intensive. It involves natural gas flow under pressure through the plant and undergoing cooling in three refrigeration cycles (so-called cascade system). The refrigerants are propane, ethane and methane. A large number of installations is associated with high costs of this method, but on the other hand it is energy efficient.

The mixed refrigerant cascade cycle is some modification of the classic cascade cycle, yet without advanced apparatus and equipment, but in this case more energy is consumed. This method uses only one compressor and one refrigerant (a mixture of hydrocarbons). Natural gas is first cooled using a propane refrigeration cycle, followed by a hydrocarbon mixture. This cycle and its variations are used more often than the classic cascade cycle mainly because of lower operating costs.

The turboexpansion cycle involves expanding a portion of the gas in a special device called a turboexpander and then cooling the gas down. The gas cooled with this method is used to liquefy another portion of the gas, which flows through the system. This method is relatively inexpensive and simple, but requires large amounts of energy.

The liquified natural gas is transported by sea or via land route. Special tankers, called methane tankers are used to transport LNG by sea, while tank cars or railroads are used to transport it by land. It should be noted that pipelines are also used in the transportation of LNG, but currently the transports are carried only over short distances from fields, for example. The liquefaction process and associated activities constitute the largest cost category estimated at about 38%. This part is most influenced by the cost of the presented liquefaction technologies.

The third link in the LNG supply chain is formed by transport, which contributes an average of 22% to the overall cost. LNG is transported on methane carriers, i.e. special vessels designed to transport LNG at very low temperatures. The cost of building them is about twice that of a tanker transporting crude oil. LNG is transported in cylindrical steel tanks with double walls, with insulation between them. The tanks are filled to 98.5% of their total volume, and about 10 m^3 of LNG is left at the bottom at unloading. This is done to keep the temperature low during the return of the emptied methane carrier and to avoid regasification during the loading of a new batch. During transport, a small amount of LNG vaporizes, but it is used effectively to generate steam for the ship's propulsion turbines.

Regasification is the process of turning LNG into natural gas in gaseous form by heating the previously liquefied raw material. There are several technologies for LNG regasification. The first of them is the SCV technology *(Submerged Combustion Vaporizers)*, which consists in heating water with flue gases (15-20℃); the pipes carrying liquefied natural gas are submerged in this water[2]. The water transmits heat to the pipes so the gas flowing in these pipes is also heated. Another LNG regasification technology is STV(Shell and Tube Vaporizers). In this method there is a closed system and two types of heating mediums: a heating medium (seawater, river water) and an intermediate medium (usually propane). The heat emitted from the turbines is picked up by the heating medium and exchanged with the intermediate medium until the latter vaporizes the LNG. Another method is ORV (Open Rack Vaporizers), where the heat source is seawater, which heats the apparatus with liquefied natural gas causing it to liquefy (Qi et al.,2019). It should have a temperature higher than 5°C. Once this is done, seawater is diverted back to the sea. It has a 5-12°C lower temperature than the surrounding water. The last method of LNG regasification is AAV (Ambient Air Vaporizers), where the heat for vaporizing LNG is taken from the ambient air. Therefore, this method is used in terminals located in warm and dry climates.

The comparison between natural gas and other fuels point to the advantages of using the blue fuel. First of all, the use of liquefied natural gas does not involve the need to store it, accumulate it or to create storage facilities. Moreover, in the process of transportation, a small amount of escaping gas is reused. The use of furnaces using natural gas is easy and safe. The high calorific value makes the energy produced significant. Natural gas burns without smoke, soot or ash, so the heat released with ash is not lost.

4. The LNG market in the UE and the perspectives of its development

Within the last decade (2011-2021) the primary energy production in the European Union, in the case of solid fossil fuels, crude oil, natural gas and nuclear energy has decreased. The production of natural gas has decreased the most, as by as much as by 63.1%, followed by solid fuels and crude oil and oil products (by 39,1 % and 36.0 %). In the same period, the production of renewable energy manifested an increasing tendency with the growth by 48.2% (cf. Fig.3).

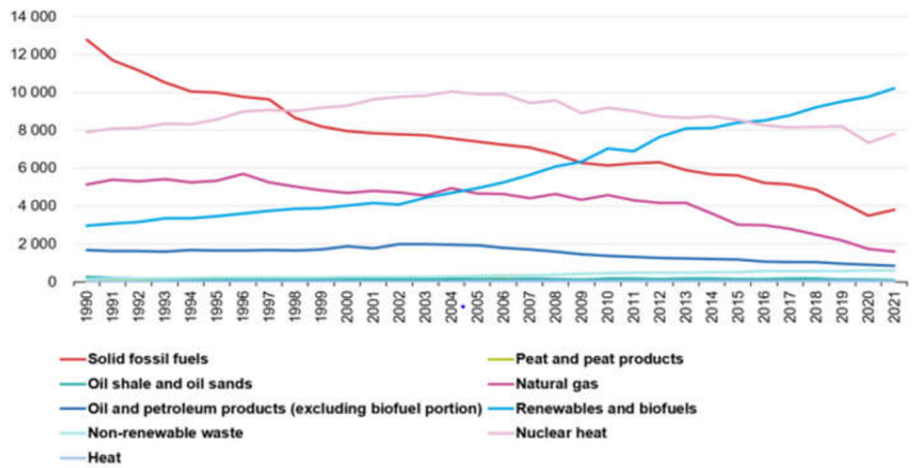

Figure 3. Primary energy production by fuel in the EU in 1990-2021
Source: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_statistics_-_an_overview, [Access: 21.11.2023]

The decrease of primary energy production in the EU within the recent decades caused some increase of the import of primary and secondary energy products. This increase was slowed down in 2020 on account of a weaker demand caused by Covid-19 pandemic to increase again in 2021. The amount of natural gas imported in 1990-2021 in the EU increased almost twice, reaching the level of 13 012 PJ. This makes natural gas the second largest imported energy product in the European Union, with crude oil being the first. This result is, however, lower by 6.9 per cent than in 2019, which was a record year for the import of natural gas (cf. Fig 4).

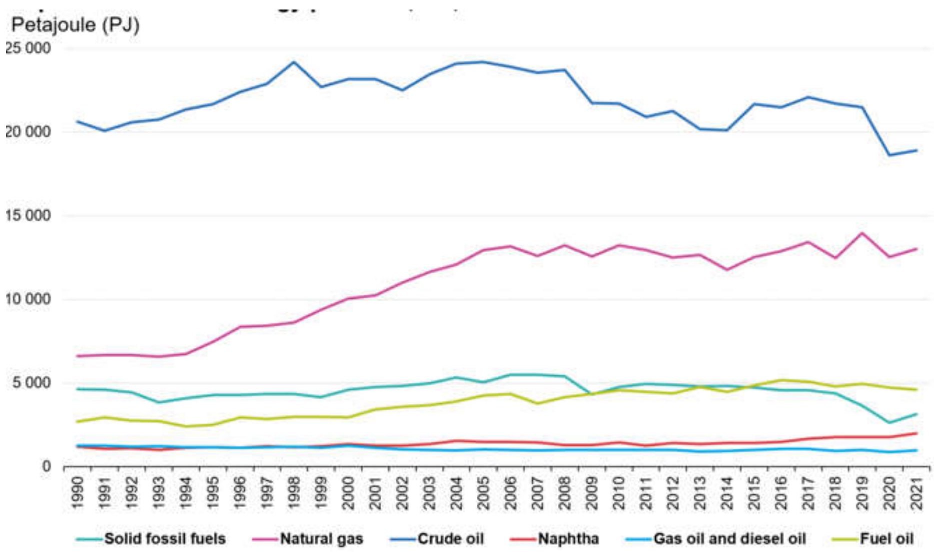

Figure 4. Imports of selected energy products, EU, in 1990-2021
Source:https://ec.europa.eu/eurostat/statistics explained/images/3/32/Imports_of_selected_energy_products%2C_EU%2C_1990-2021_Petajoule_%28PJ%29.PNG [Access: 18.11.2023]

Given the highly developed onshore gas pipeline network, as well as bilateral agreements containing privileged pricing, and also other agreements with EU member states, Russia has so far been the main supplier of gas to the EU since the 1990s. One could even speak of the institutionalization of the energy dialogue between Russia and the EU, which started with the declaration signed at the EU-Russia summit in Brussels, in October 2001, known as "The Future Direction of the Energy Dialogue between the European Union and the Russian Federation." All these circumstances resulted in the share of Russian gas in the overall total gas imports by EU countries reaching the level of 35-40%.

Russia-Ukraine war changed the reality of the gas trade between Russia and the EU. The winter of 2022/2023 created an unprecedented anxiety for the European Union connected with the loss of the Russian gas supplies, which was the outcome of the imposed sanctions and the lack of any alternative at an affordable price. In order to prevent any gas supply disruptions, the European took actions to obligate the member states to guarantee 80% filling of gas storage facilities at the beginning of the 2022/23 winter season and up to 90% for subsequent years, in addition to a number of diversification measures aimed at obtaining gas from sources different than Russia. To this end, the European Commission has given the green light for member states, first of all, to increase their LNG import capacity, either by expanding existing onshore regasification facilities or chartering floating storage and regasification units (FSRU).

Since the end of 2021 a monthly gross import of LNG to UE has significantly increased, which is the outcome of the exceptional situation in the gas market and the necessity to fill the storage facilities with gas. Since the beginning of 2022, the EU has imported 98 billion m^3 of LNG, which is 39 billion m^3 than at the same moment of 2021; between January and September 2022 the EU imported more than in the record breaking year 2019 (Shell LNG Outlook 2023).

In 2022, the regasification capacity of onshore LNG terminals in the EU27 countries will be 141 billion m^3 of natural gas per year, with another 28 billion m^3 of natural gas per year in FSRU floating terminals. This volume is sufficient to satisfy approximately 40% of total current gas demand. However, there are bottlenecks and infrastructure constraints in some regions of the European Union. Some EU countries, such as Germany, are increasing their LNG import capacity through accelerated investment in LNG terminals. Based on the list of EU projects of common interest (*PCI- Projects of Common Interests*), the LNG strategy includes a list of key infrastructure projects that are necessary to ensure that all EU countries can benefit from LNG (these projects include, for example, the construction of the Gdansk LNG terminal or the CyprusGas2EU LNG terminal, (Document 32022R0564 Commission Delegated Regulation (EU) 2022/564 of November 19, 2021 amending Regulation (EU) No 347/2013 of the European Parliament and of the Council as regards the Union list of projects of common interest). For any new infrastructure, commercial viability is very important; i.e. in the case of the LNG terminal, its use throughout the region or the choice of lower cost and more flexible technologies, such as floating storage and regasification units (FSRUs), which can significantly improve its profitability.

Modern LNG infrastructure in EU countries is relatively developed, yet its development will be intensified over the next few years in the context of events in Ukraine. Seven onshore LNG terminals are located in Spain, which is the largest number in Europe (Cf. Fig.6).

Figure 5. Land LNG terminals in Europe
Source: https://energy.ec.europa.eu/system/files/2022-02/EU-US_LNG_2022_2.pdf [Access: 15.11.2023]

Their total regasification capacity is 67.1 bcm of natural gas per year (Cf. table 1).

Table 2. LNG terminals in Spain

Location of the terminal	Year of construction	Capacity
Barcelona	1968	17.1 bcm
Huelvie	1988	11.8 bcm
Cartagena	1989	11.8 bcm
Bilbao	2003	7.0 bcm
Sagunto	2006	8.8 bcm
Mugardos	2007	3.6 bcm
Gijón (El Musel)	2012	7.0 bcm

Source: Own elaboration based on https://energy.ec.europa.eu/topics/oil-gas-and-coal/liquefied-natural-gas_en6 [Access: 18.11.2023]

On the Iberian Peninsula, apart from 7 Spanish terminals, there is also an LNG terminal in Sines, Portugal, which has been in operation since 2004, with an annual capacity of 7.6 bcm of natural gas.

France ranks second with respect to the regasification capacity of the onshore terminals. The total of its four facilities is 33.0 bcm of natural gas per year. The oldest of the terminals is Fos Tonkin, which has been in operation since 1972. Its capacity is only 1.5 bcm of natural gas per year and is therefore it is the smallest LNG terminal in the EU. Another long-operating terminal is the Montoir de Bretange, located on the Bay of Biscay, which has been in operation since 1980. The terminal's throughput is 10.0 bcm of natural gas per year. The French Fos Cavaou terminal has been in operation since 2010, with an annual capacity of 8.5 bcm of natural gas. There are plans to expand it by 1.5 bcm of natural gas per year and 2.0 bcm of natural gas per year from 2030. The terminal will thus be able to supply 12 bcm of natural gas per year from the beginning of the next decade. Dunkirk is home to France's newest and largest LNG terminal, which started to operate in 2016. Its capacity is 13.0 bcm of natural gas per year.

These EU countries also have one onshore terminal each: Belgium, Greece, the Netherlands, Poland and Italy. One of the oldest installations of this type in the EU is the Panigaglia terminal, operating in Italy since 1971, with a capacity of 3.4 bcm of natural gas per year.

In Belgium, in Zeebruge, an LNG terminal started to operate in 1987, whilst its current capacity is 11.4 bcm of natural gas per year. There are plans to expand it by 3.9 bcm in 2024 and 1.8 bcm in 2026. After 2026, the terminal will be able to deliver 17.1 bcm of natural gas per year, thus it will become one of the largest facilities of its kind in the EU.

On the south of the Continent, in Greece, in the vicinity of Athens, there is an LNG terminal,

Revithoussa. Since 2011 in Rotterdam, the Gate terminal has been in operation with the current throughput of 12.0 bcm of natural gas per year. There are plans to expand it by 1.5 bcm in 2024 and by 2.5 bcm of natural gas per year in 2026. This terminal, after 2026 will develop an ability to supply 16 bcm of natural gas per year.

In 2016, Świnoujście, an LNG terminal started to operate and its current capacity is 6.2 bcm of natural gas per year in. There are plans to expand it by 2.1 bcm of natural gas per year already in this year.

The LNG supply, in some sense saved the EU countries from the loss of gas supply liquidity during the winter of 2022/23 and the disruptions related to the loss of energy security. Therefore, EU plans for the construction of onshore LNG terminals include the construction of new installations in Estonia – two terminals (Paldiski – 2025 and Tallinn), in Germany – two terminals (Brunsbuttel – 2023 and Stade – 2026) and in Italy (Porto Empedocle – 2024).

Between January and September 2022, the largest exporters of LNG to the EU were the United States (44%), Russia (17%) and Qatar (13%). The role of the United States in gas supplies to the EU is continually increasing. At the end of March 2022, the EU and the US passed a joint declaration on increasing LNG trade and expressed their common interest in the further increase of the LNG imports to the EU from the US by 15 bcm in 2022, compared to the preceding year. This objective was achieved at the end of August 2022, 4 months ahead of schedule. Currently, the countries in Europe which have access to LNG import terminals and liquefied natural gas markets are much more resilient to potential supply disruptions than those dependent on a single gas supplier.

The analysis of the data for the third quarter of 2023 and their comparison it with those concerning the third quarter of 2021, it can be concluded that as a result of the increase in LNG import capacity, the structure of the share of countries in the supply of gas to EU member states has remodeled (cf. Fig.6). In addition to the record inflow of LNG, EU member states have also started to diversify their gas imports via pipelines from countries other than Russia. An example is the opening of the Baltic Pipe in the autumn of 2022. The EU has adopted a voluntary target of reducing gas demand by 15 percent between August 1, 2022 and March 31, 2023, compared to a five-year average. This commitment was followed by a 10 percent drop in European natural gas demand (or 54 billion cubic meters) in 2022. It's worth observing that this is the largest decline in consumption of this commodity in history. The result is a smaller share of Russia in EU natural gas imports, which decreased from the level of 39% in the third quarter of 2021 to 12% in the third quarter of 2023 (see Figure 6).

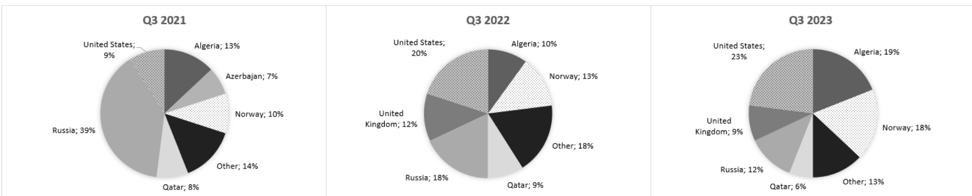

Figure 6. The main gas suppliers to the EU member states in Q3 2021, 2022 and 2023

Source: the Author's own elaboration on the basis of Main partners for extra-EU imports of natural gas updated in Nov 2023, https://ec.europa.eu/eurostat/statistics explained/index.php?title=File:Main_partners_for_extra-EU_imports_of_natural_gas_upd_Nov_2023.png [Access: 18.11.2023]

In the third quarter of 2023, the highest percentage share of EU gas imports (23%) belonged to the United States. From 2021 to 2023, the share of Algeria, the United Kingdom and Norway in total EU gas supplies also increased.

Conclusions

The dependence of the European Union from the Russian natural gas has been a controversial and widely discussed issue even long before Russia's invasion in Ukraine. The security of the energy supplies in the general energy security of the EU has long been one of the key priorities of the European Commission. However, once seen from the point of view of stable and reliable supplies of energy resources, it has been largely overshadowed by other challenges with the energy transition being one of them.

The EU has imposed extensive and unprecedented sanctions on Russia after its invasion of Ukraine, yet Gazprom and other Russian gas suppliers have so far escaped the packages of the EU's sanctions. This is because the 27 EU member states must vote as a bloc, and several EU countries, such as Hungary, Austria and Slovakia are still dependent on receiving gas from Gazprom and thus continue to import Russian gas.

The European Union with its member states have taken a number of measures aiming at increasing the security of supplies and market resilience before the 2022/23 winter season. The above measures, in particular, concern the regulation of gas storage and the determination of minimum filling levels in storage facilities. The solution for these problems turned out to be the possibility of LNG imports, which reached unprecedented levels in the European Union and remodeled the EU gas supply market, and, as a result such countries as the USA, Algeria, Norway, Qatar have become the main partners in this respect. This allowed to avoid major disruptions in supplies, which are one of the pillars of energy security. In this context, the reduction of Russian gas supplies from 39% in 2021 to 12% in Q3 2023 and the securing of LNG supplies on a permanent basis seems to be a great success.

In the context of the need to secure a larger amount of the LNG in Europe, the LNG suppliers and the developers of the new LNG export projects (also in the USA and Qatar), intending to replace the Russian pipeline gas, are now asking themselves whether the European buyers are ready to commit to long-term (i.e., more than 10 years) fixed-price LNG contracts, which is crucial for financing LNG infrastructure projects. The answer does not seem to be simple. The European Union needs large quantities of LNG by 2030, but the trajectory is less clear. It depends on many factors, including the speed at which alternative energy sources such as wind power and hydrogen will be developed, as well as the long-term outlook for LNG prices and many other economic (conjunctural) and political factors.

References

1. Augutis, J., Krikstolaitis, J., Martisauskas, L., & Peciulyte, S. (2012). *Energy security level assessmenttechnology*. Applied Energy, 97, 143-149. https://doi.org/10.1016/j.apenergy.2011.11.03.
2. Brunner, G (2013). *Gas extraction: an introduction to fundamentals of supercritical fluids and the application to separation processes*. Springer Science & Business Media.
3. Cipollaro, A., & Lomonaco, G. (2016). *Contributing to the nuclear 3S's via a methodology aiming at enhancing the synergies between nuclear security and safety*.
4. Consolidated version of the Treaty on the Functioning of the European Union Official Journal of the European Union2012/C 326/01.
5. European Parliament resolution of 7 April 2022 on the conclusions of the European Council meeting of 24-25 March 2022, including the latest developments of the war against Ukraine and the EU sanctions against Russia and their implementation (2022/2560(RSP)).
6. European Parliament resolution of 19 May 2022 on the social and economic consequences for the EU of the Russian war in Ukraine – reinforcing the EU's capacity to act (2022/2653(RSP)).
7. European Commission, Brussels, 18.5.2022, COM(2022) 230 final Communication From The Commission To The European Parliament, The European Council, The Council, The European Economic and Social Committee And The Commitee of the Regions. *REPowerEU Plan*{SWD(2022) 230 final}.
8. Esperanza Mata Pérez D.L.M, Scholten D., Smith Stegen K. (2019). *The multi-speed energy transition in Europe: Opportunities and challenges for EU energy security.* Elsevier Energy Strategy Reviews 26 (2019) 100415, https://doi.org/10.1016/j.esr.2019.100415
9. *Future Shocks 2023: Securing energy supply in Europe,* https://epthinktank.eu/2023/08/10/future-shocks-2023-securing-energy-supply-in-europe/, https://ec.europa.eu/eurostat/statistics explained/index.php?title=Energy_statistics_-_an_overview, (access 20.11.2023).
10. Goldthau C.A., Richard Youngs (2023).*The EU Energy Crisis and a New Geopolitics of Climate Transition*, September 2023, JCMS Journal of Common Market Studies 61(S1), DOI: 10.1111/jcms.13539
11. Howell N., Byrne R., Landray T.(2023). *Report on LNG in Europe in 2023*. King&Spalding.
12. *Imports of selected energy products,* EU, in 1990-https://ec.europa.eu/eurostat/statistics explained/images/3/32/Imports_of_selected_energy_products%2C_EU%2C_1990-2021_Petajoule_%28PJ%29.PNG, [Access: 18.11.2023].

13. Jackson R.E., Gorody A.W, Maye B., Roy J.W, Ryan M.C, Van Stempvoort D R, (2013). *Groundwater Protection and Unconventional Gas Extraction: The Critical Need for Field-Based Hydrogeological Research*, Groundwater , Volume 51, Issue 4, July/August 2013, Pages 488-510, DOI: 10.1111/gwat.12074.
14. *Land LNG terminals in Europe,* https://energy.ec.europa.eu/system/files/2022-02/EU-US_LNG_2022_2.pdf [Access: 15.11.2023].
15. Löschel, A., Moslener, U., & Rübbelke, D. (2010). *Indicators of energy security in industrialised countries.* Energy Policy, 38(4), 1665-1671. https://doi.org/10.1016/j.enpol.2009.03.061.
16. *Main partners for extra-EU imports of natural gas updated in Nov 2023,* https://ec.europa.eu/eurostat/statistics explained/index.php?title=File:Main_partners_for_extra-EU_imports_of_natural_gas_upd_Nov_2023.png. [Access: 18.11.2023].
17. Månsson, A., Johansson, B., & Nilsson, L. (2014). *Assessing energy security: An overview of commonly used methodologies.* Energy, 73(14), 1-14. https://doi.org/10.1016/j.energy.2014.06.073
18. Maxwell D., Zhu Z. (2015). *Natural gas prices, LNG transport costs, and the dynamics of LNG imports.* Energy Economics,Volume 33, Issue 2, March 2011, Pages 217-226.
19. *Primary energy production by fuel in the EU in 1990-2021*, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_statistics_-_an_overview [Access: 21.11.2023].
20. *Progress in Nuclear.* Energy, 86, 31-39. https://doi.org/10.1016/j.pnucene.2015.09.013
21. Pach-Gurgul A. (2015). *The energy-Climate Package and Realisation of its Objectives within the Context of the Sustainable Development of the European Union*. Central European Review Of Economics & Finance, Vol. 10, No. 4 (2015), pp. 75–90.
22. Qi CH., Yi Ch., Wang B., Wang W, Xu, J. (2019). *Thermal performance analysis and the operation method with low temperature seawater of super open rack vaporizer for liquefied natural gas, Applied Thermal Engineering*, Volume 150, Pages 61-69. Volume 150, https://doi.org/10.1016/j.applthermaleng.2018.12.152.
23. Qi Ch., Wang W., Wang B., Kuang Y., Xu J. (2016). *Performance analysis of submerged combustion vaporizer.* Journal of Natural Gas Science and Engineering, Volume 31, 2016,
24. Pages 313-319, ISSN 1875-5100, https://doi.org/10.1016/j.jngse.2016.03.003.
25. Regulation (EU) 2022/1032 of the European Parliament and of the Council of 29 June 2022 amending Regulations (EU) 2017/1938 and (EC) No 715/2009 with regard to gas storage (Text with EEA relevance).

26. Roman-White S.A., Littlefield J.A, Fleury K.G., Allen D.T, Balcombe P., Konschnik K. Ewing J., Gregory B. Ross G.B., George F (2021). *LNG Supply Chains: A Supplier-Specific Life-Cycle Assessment for Improved Emission Accounting*, *ACS Sustainable Chemistry and Engineering.*, 10857-10867, August 3, 2021. https://doi.org/10.1021/acssuschemeng.1c03307.
27. *Shell LNG Outlook 2023*. https://www.shell.com/energy-and-innovation/natural-gas/liquefied natural gaslng/lngoutlook2023/_jcr_content/root/main/section_599628081_co/promo_copy_copy/links/item0.stream/1676487838925/410880176bce66136fc24a70866f94129 5eb70e7/lng-outlook-2023.pdf.
28. Sovacool, B.K. (2013). *An international assessment of energy security performance.* Ecological Economics, 88, 148-158. https://doi.org/10.1016/j.ecolecon.2013.01.019.
29. Tagliapietra S., Zachmann G., Edenhoferb O., Glachant J.M., Linares P., Loeschel A. (2019). *The European union energy transition: Key priorities for the next five years.* Energy Policy Volume 132, September 2019, Pages 950-954.
30. *Main partners for extra-EU imports of natural gas updated in Nov 2023*, https://ec.europa.eu/eurostat/statistics explained/index.php?title=File:Main_partners_for_extra EU_imports_of_natural_gas_upd_Nov_2023.png [Access: 18.11.2023].
31. Yergin, D. (2006). *Ensuring Energy Security. Foreign Affairs*, 85(2), 70-71.
32. Van de Graaf, T., & Colgan, J. (2017*). Russian gas games or well-oiled conflict? Energy security and the 2014. Ukraine crisis.* Energy Research & Social Science, 24, 59-64,https://doi.org/10.1016/j.erss.2016.12.01.
33. Wang, B., Wang, Q., Wei, Y.-M., & Li, Z.-P. (2018). *Role of renewable energy in China's energy security and climate change mitigation: an index decomposition analysis. Renewables Sustainability Energy Review*, 90, 187-194. https://doi.org/10.1016/j.rser.2018.03.012.