« Could U.S. LNG challenge Russian Gas within the European Union in the long term ?”

By

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EXECUTIVE SUMMARY

Natural gas became one of the largest fossil fuel resource consumed among the past decades. Thanks to its lower carbon content compared to oil or coal, natural gas is used as a source of energy mainly for power generation in many region across the globe and seen as an environmentally friendly commodity, helping the energy sector and the global economy to decrease its CO2 emissions by replacing the dirtiest fossil fuel to produce electricity. This recent surge of natural gas can also be explained by the diversification of the possibilities to supply gas in many region of the world, historically by pipeline and more recently thanks to Liquefied Natural Gas (LNG), allowing isolated market to be supplied via vessels transporting the gas in its liquid form. It also allows the demand side of the market to diversify more efficiently its sources of supply such as in Europe or in Asia, which form the bulk of the natural gas demand. The European Union (EU) is the second biggest gas market in the world after Asia, being mainly supplied by Russia thanks to its vast network of pipeline, the EU struggled to diversify its sources of supply to increase energy security within the eurozone and build a resilient gas market, able to resist to shocks and disruption in the gas sector. Russia covers approximately 40% of the European gas demand each year, some issues in 2006 and 2009 between Ukraine and Russia led to a shortage of natural gas in many European countries, with few other alternatives to diversify their natural gas supplies. Since then, the U.S. shale boom allowed the country to become the biggest gas producer and recently became a net exporter of natural gas, mainly thanks to LNG. Europe is attracting LNG vessels from the other side of the Atlantic and expect to attract more in the coming years to reduce the influence of Russia over the European gas market. This study will assess whether U.S. LNG has the capacity to counterbalance Russian gas in the European Union in the future, through a description of the global gas market and a quantitative analysis of the future shape of the European gas market.

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ABBREVIATIONS

Bcf: Billion cubic feet

Bcm: Billion cubic meter

EIA: Energy Information Administration

EU: European Union

FERC: Federal Energy Regulatory Commission

IEA: International Energy Agency

LNG: Liquefied Natural Gas

MMbtu: Million British Thermal Unit

Tcf: Trillion cubic feet

Tcm: Trillion cubic meters

INTRODUCTION

"God must have been a shipowner. He placed the raw materials far from where they are needed and covered two thirds of the world into water." This sentence belongs to Earling Naess, a Norwegian shipowner and businessman who built a flourishing company during the mid-20th century. This used to be true for a long time, before the rise of multilateral trade agreements between countries, the establishment of the World Trade Organization and the large scale development of the shipping sector. From 1960 to 2018, the global Gross Domestic Product grew by an average of 3,88% [1], involving a massive growth in energy consumption to support the development of the modern economy. Due to the composition of the global energy mix, mainly made of coal and oil, carbon dioxide emissions rose from 9.3 billion tons in 1960 to 32.3 billion tons in 2016 according to the International Energy Agency (IEA). Oil is the symbol of this rise in emissions and consumption, as it accounts for roughly a third of global energy consumption [2] and this commodity is delivered by pipeline or tankers. More than 9000 tankers are shipping oil worldwide, representing 11% of the world's total number of vessels [3]. Due to the physical composition of oil, it was easily feasible to transport the fossil fuel by tanker from a producing country to a resourceless one, allowing oil to become a global commodity. Things were very different concerning natural gas, as for a long time, it was only economically possible to transport it over long distances by pipelines. But pipelines have their limitations, concerning the distance at which the gas can be transported and the security of the infrastructure.

In 1820, British scientist Michael Faraday successfully managed to chill natural gas into a liquefied form, currently known as Liquefied Natural Gas (LNG). For this purpose, natural gas, also known as Methane (CH_4) is cooled down to around -162°C (-259°F), at which temperature the gas turns into a liquid and is 600 times smaller than its volume in its gaseous state, according

to the Energy Information Administration [4]. This process allows the gas to be stored in a plant or in an LNG carrier, to be shipped by the sea. In 1959, the first LNG carrier, Methane Pioneer, left the Louisiana Gulf Coast in the U.S. to deliver natural gas to the United Kingdom. But this new supply chain for natural gas was marginal compared to pipelines capacity. Due to the high cost of the infrastructure to transport gas under its liquid form and the dominance of oil and coal at that time, LNG was not considered as a viable option to transport gas. Since then, thanks to an improvement in the technology, the financing of projects, the discovery of new gas fields and the backing from governments and institutions, the LNG sector has been booming for the past 15 years and is now fiercely competing with pipelines delivery. In 2016, the global gas trade by long-distance transit route was 68% by pipeline with 737.5 billion cubic meters (bcm) and 32% by LNG carrier with 346.6 bcm [5]. In 2018, the global LNG fleet crosses the 500-vessel mark according to S&P Global Platts, showing the fast-paced development of this particular sector of the energy market.

Going more into detail concerning the research question of this thesis, the European Union (EU) has historically always been a major purchaser of Russian natural gas. In 2018, extra-EU imports of natural gas from Russia accounted for 40.2% of the total imports of natural gas in the region [6], reflecting the stranglehold Russia has on this key resource over the EU. More concerning are the inequalities among the EU countries relying on Russian gas. Eastern European countries and Baltic countries are importing 100% of their gas from Russia, such as Bulgaria, Estonia, Finland, Latvia, Lithuania or Sweden and over 50% for many others [7]. Following gas supply disruption occurring in 2006 and 2009, due to commercial disputes between Russia and Ukraine, the European Union was left with little options to fill in the shortage, as Russia is the main trade partner of natural gas for the EU and 80% of the Russian gas for Europe passed via Ukraine at that time [8]. The European Commission decided to take action on two major issues: to build a robust, global European gas network, resilient to gas

shortage for several months and to explore and build new gas routes to diversify gas supplies and achieve the security of supply, as required by the article 176A of the Lisbon Treaty [9].

At the same time, on the other side of the Atlantic, a new revolution was taking place, the Shale revolution. In the U.S., thanks to the development of fracking, new oil and gas fields, previously inaccessible, started to be exploited. In 2014, the U.S. became the leader in global petroleum and natural gas production, surpassing Saudi Arabia for oil and Russia for gas. The U.S. is producing around 11.3 million barrels per day (b/d) of crude oil and more than 100 billion cubic feet (bcf) of natural gas per day in 2018 or 2.83 bcm per day [10]. Since 2017, the U.S. is a net exporter of natural gas and in 2018 it has been able to export 3.61 Trillion cubic feet (Tcf). 70% of these exports were by pipeline, mainly to supply Mexico and the remaining 30% were under the form of LNG, shipped to various destinations [11]. One of them is the European Union; on both sides of the Atlantic, many liquefaction or regasification plants have been built or are planned to come on line in the next few years. Cooperation has been implemented among the two blocs in this particular sector and since April 2016, where the EU received the first cargo from the US, LNG exports to the EU have been increasing by 272%. In March 2019, the highest volume of EU-U.S. trade in LNG has been recorded, with more than 1.4 bcm [12].

Having regards to these different issues, one can see that the EU is trying to find a balance in the gas sector to achieve security of supply and find new alternatives to Russian gas, while the U.S., with a rising production of natural gas, wants to find new economic partners, able to buy large quantities of the fossil fuel. Ultimately, Russia desires to keep its market share in Europe, its biggest client, while finding other countries, like in Asia, to diversify its sales of natural gas. This brings us to the core subject of this thesis, by analyzing if the U.S. could become a long-term reliable partner to the EU in the gas market and reduce the share of Russian gas in the

eurozone, by providing a descriptive research method of the current state of the gas sector and then a forecast of this fast-growing market in the long-term with a focus on the EU.

1. Overview of the natural gas sector

Before analyzing in detail the possibility for the U.S. to challenge Russian gas in Europe over the next decades to come, an overview of the natural gas market in the 3 different zones should be provided in order to fully understand what is at stake for each of the player and why the European Union should diversify its gas supplies.

1.1 The gas sector in the European union

The European Union is mainly importing gas from third countries, due to the low level of its indigenous production. Being a major net importer of natural gas, the EU had to increase the diversification of its sources of supply, its storage capacity and the interconnection between the different gas networks within the eurozone. LNG appeared recently as another solution to enhance the energy security.

1.1.1 Natural gas production within the EU

Several countries in Europe are producing natural gas. In 2018, internal production of natural gas accounted for roughly 120 bcm in the European Union [13]. But this amount is decreasing every year because of the ageing natural gas fields discovered in Europe, mainly located in the North Sea and is not sufficient to cover the gas demand.

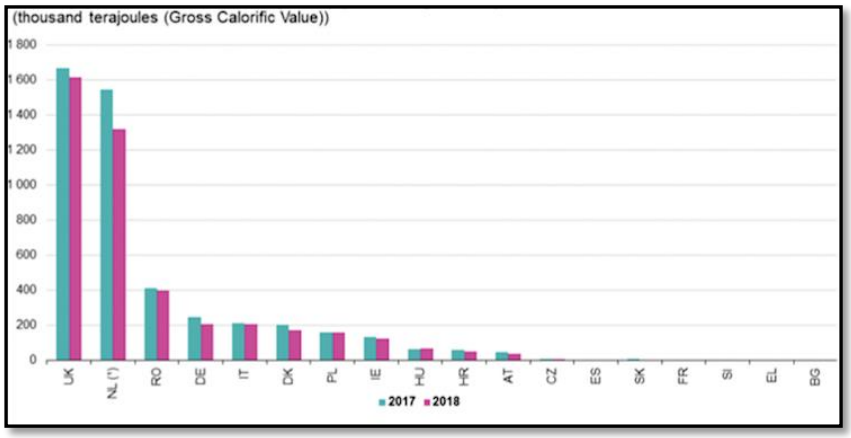

Figure 1: Primary production of natural gas, by producing country, 2017-2018 (Source: Eurostat)

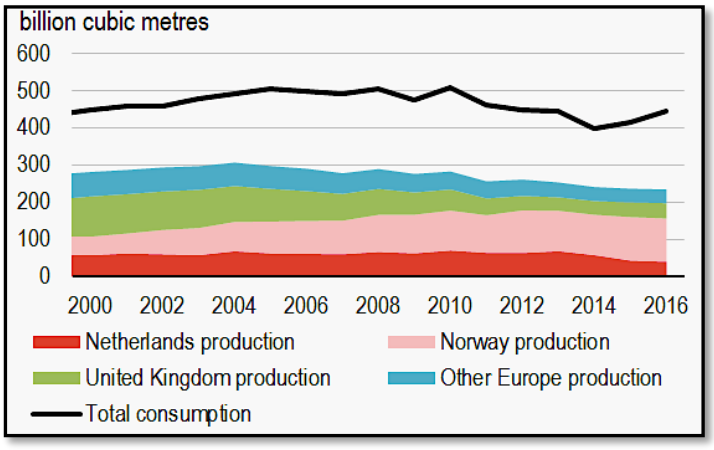

Figure 2: Gas production and consumption in OECD Europe (Source:BP Statistical Review of World Energy)

As the two figures suggest, the production of natural gas among EU countries (Norway should be excluded from the Figure 1) is declining, mainly from the two main European producers, the United Kingdom and the Netherlands. According to the Market Observatory for Energy of the European Commission, in the fourth quarter of 2018, the UK gas production fell by 6% and the one for the Netherlands fell by 16% in year-on-year comparison. This trend highlights the weakness of the gas production in Europe and the reduction of the output through time. To cover the needs of the citizens and the industry, the EU has to look for other options and import massive amounts of natural gas every year to fill in the gap from its own production and match the consumption.

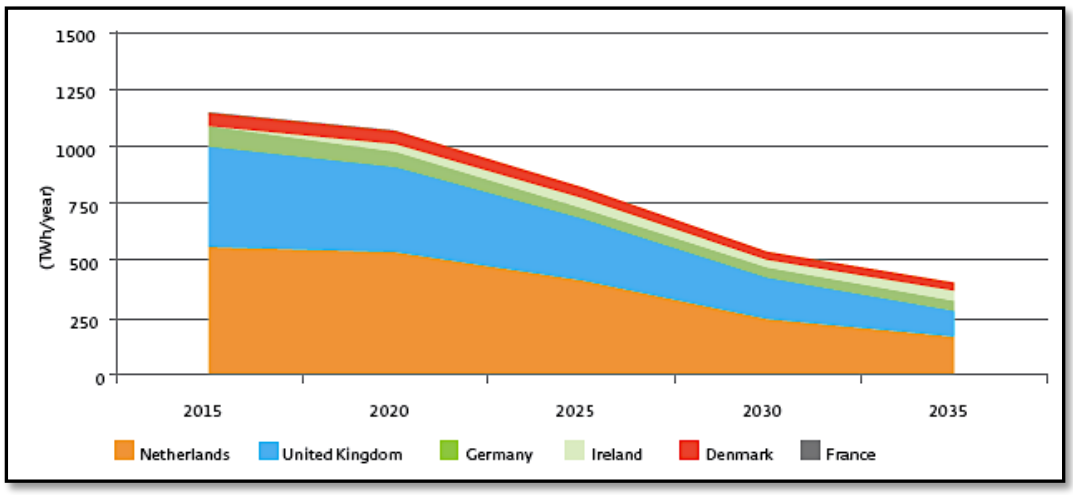

Figure 3: Conventional gas production in North-West Europe (Source: Gasunie Scenario)

1.1.2 Natural gas import within the EU

The EU is a major importer of natural gas due to its low level of indigenous production. In 2018, the total import bill for natural gas was estimated at 90 billion euros according to the European Commission with 401.1 bcm of natural gas imported. Among the different suppliers, Russia is the first provider of natural gas to Europe with 155 bcm supplied to the EU, more than the whole domestic production of the eurozone. That number increased by 5.5 bcm compared with a year earlier. According to Gazprom in its delivery statistics, 200.8 bcm of natural gas were supplied to Europe including Turkey and 176 bcm of natural gas was supplied to the European Union in 2018. Depending on which countries are included to provide the exports numbers, results may change. The Gazprom number is more accurate as it gives the detail of export by country, which makes more feasible to see which countries are included for the calculations.

Then, Norway is the second biggest trade partner 108.4 bcm supplied in 2018 compared to more than 110 bcm a year earlier, showing the decline of the North Sea production. LNG is the third import source for the EU, with almost 50 bcm supplied to the EU, it is 2.4 bcm more compared to 2017.

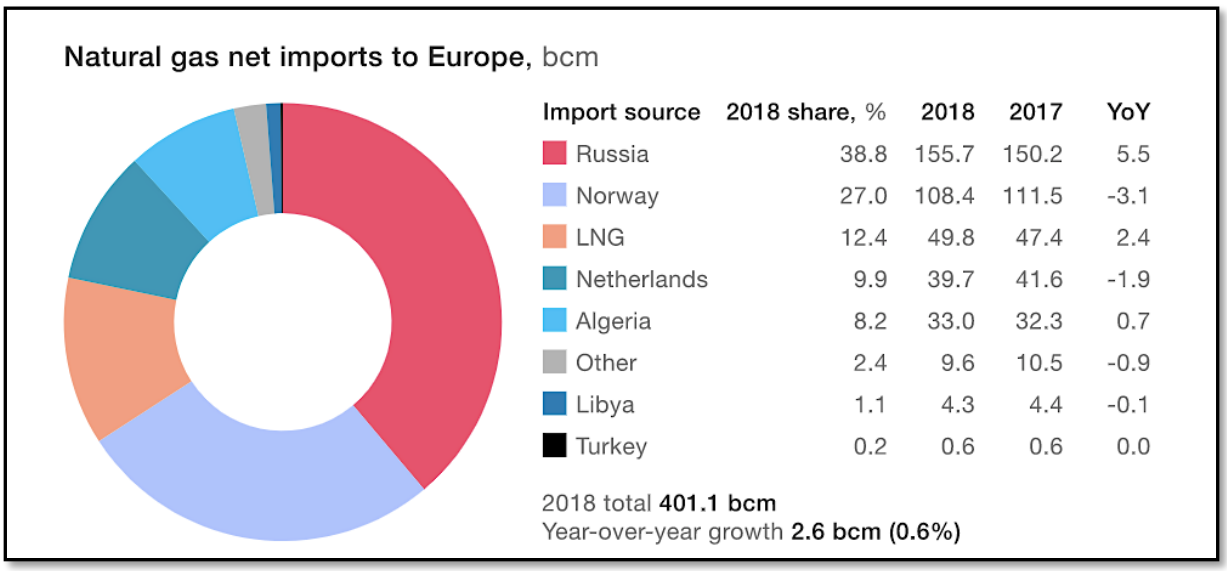

Figure 4: Natural gas net imports to Europe, 2018
(Source: Energy Insights EU PipeFlow; Entsog; ALSI;AGSI)

What one can observe for the past 10 years is that the domestic production of the EU decreased by 33% from 2010 until 2017, and this trend is set to continue. The strategy of the EU is to substitute this loss with external imports. According to the Energy Information Administration (EIA), Russian shares of the natural gas market in the EU are on the rise regarding to the past few years and apart from Norway, no other country is able to counterbalance this stranglehold. But Norwegian production is shrinking year after year and the country will face a continued loss in its market shares in the European gas market. 2014 was the year with the lowest amount of gas consumption within the EU, with only 40 bcf/day supplied to the market versus 47 bcf/day in 2017; 2014 was also the year with the lowest amount of LNG imports, but through the following years, LNG gained market shares in the composition of the gas market within the EU and is now in third position in terms of volumes imported.

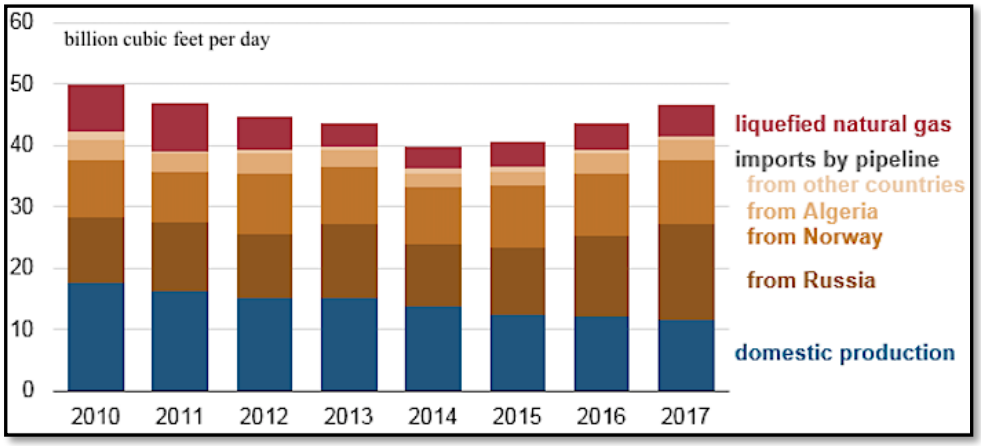

Figure 5: Europe natural gas supply composition, 2010 – 2017
(Source: Energy Information Administration)

1.1.3 Demand of natural gas in the European Union

Natural gas demand is mainly driven by seasonal factors, the price of natural gas and the availability of other sources of production to compete with this natural resource like in electricity production. Natural gas is most likely to be heavily consumed during winter and more generally from September until March or April. As the figure below shows, EU gas consumption in winter increase by a two-fold compared to summer (May – September).

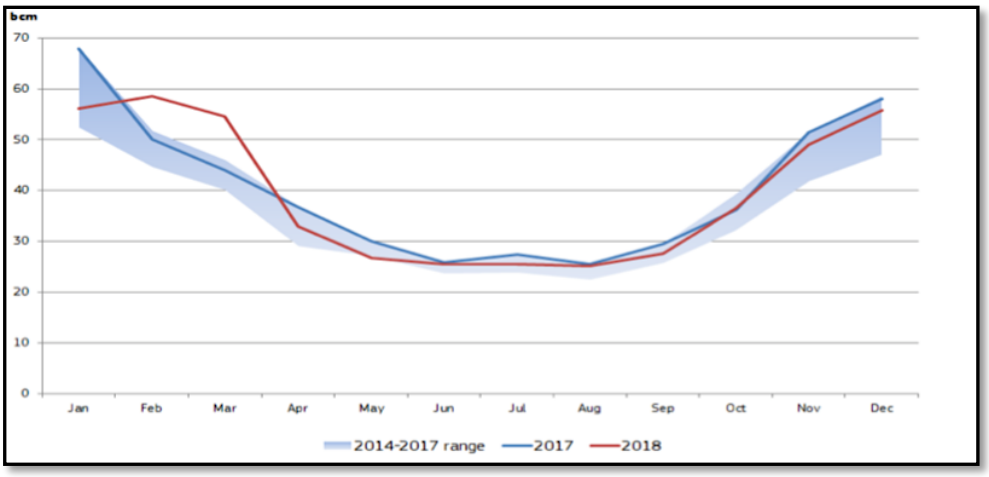

Figure 6: EU gas consumption, 2017-2018 (Source: Eurostat, 2019)

From 1990 until 2018, natural gas consumption in the EU passed from 13 816 thousand terajoules to 18 167 thousand terajoules with several peak above 20 000 thousand terajoules for some years [14]. This represents an increase of more than 30% on the demand side of the natural gas market and an average consumption of 17 784 thousand terajoules for this timeline. Due to the falling domestic production of natural gas in the eurozone, the share of extra EU-imports is rising every year and this trend is set to continue to match the rising demand.

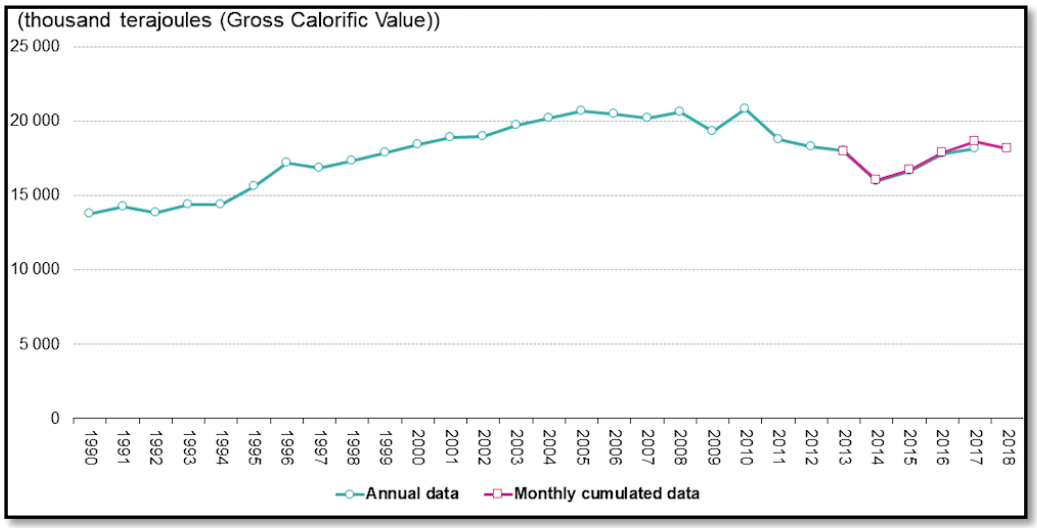

Figure 7: Gross inland consumption of natural gas, EU, 1990-2018 (Source: Eurostat)

EU natural gas production for 2018 reached 4388 thousand terajoules, falling by 8,1% compared to 2017 according to Eurostat. In comparison to the consumption of natural gas which accounted for 18 167 thousand terajoules the same year, the domestic production of the EU can

only cover 20 to 25% of the demand. This means that between 75 to 80% of the natural gas has to be imported in Europe to support the consumption of the eurozone.

Related to a falling domestic production on the supply side and a rising demand in natural gas is the natural gas dependency of the European Union, that is to say the dependency from the bloc towards external suppliers of the fossil fuel.

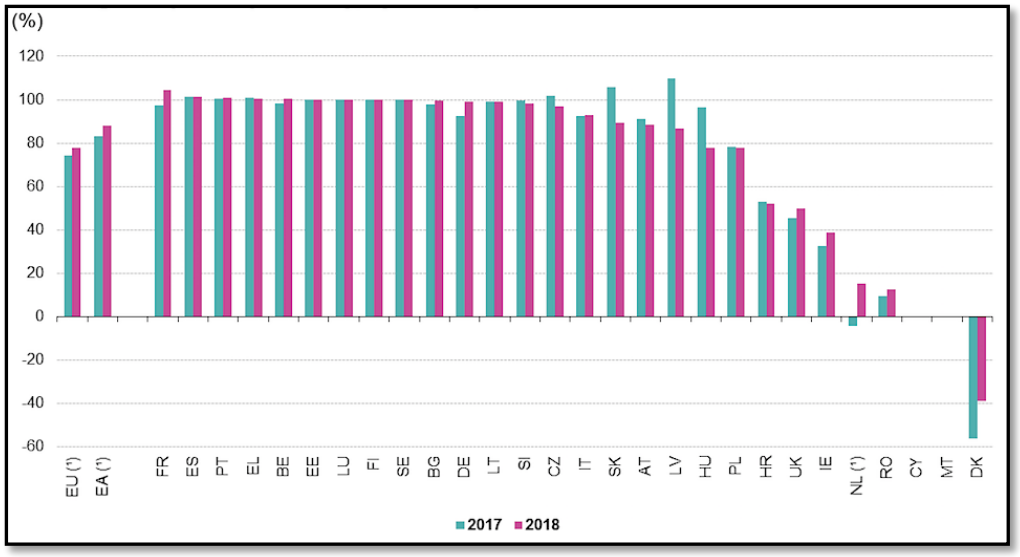

Figure 8: Natural gas import dependency by country, 2017-2018 (Source: Eurostat)

As shown in the figure, the average dependency of the EU on natural gas imports rose from 74,4% in 2017 to 77,9% in 2018, suggesting that the EU28 will need to increase and secure its imports in the next decades. 15 member states have a natural gas dependency above 90% and Denmark is the last country remaining a net exporter of natural gas in the EU, as Netherlands became a net importer in 2018 due to a falling domestic production.

1.1.4 Natural gas storage and interconnection in the European Union

In order to mitigate the effects of natural gas dependency and external suppliers' control of the European gas market, European Institutions, alongside national regulators and energy companies in the EU took the initiative to build one of the biggest gas market and increase the resilience of the eurozone. In order to do so, the storage capacity in Europe and the

interconnection between the different member states have been a strong area of development to allow the member states to supply gas to each other in case of a shortage.

Gas storage in the EU28 represents 21% of annual gas consumption according to Gas Infrastructure Europe with slightly more than 100 bcm of storage capacity across 156 storage units spread across the EU [15].

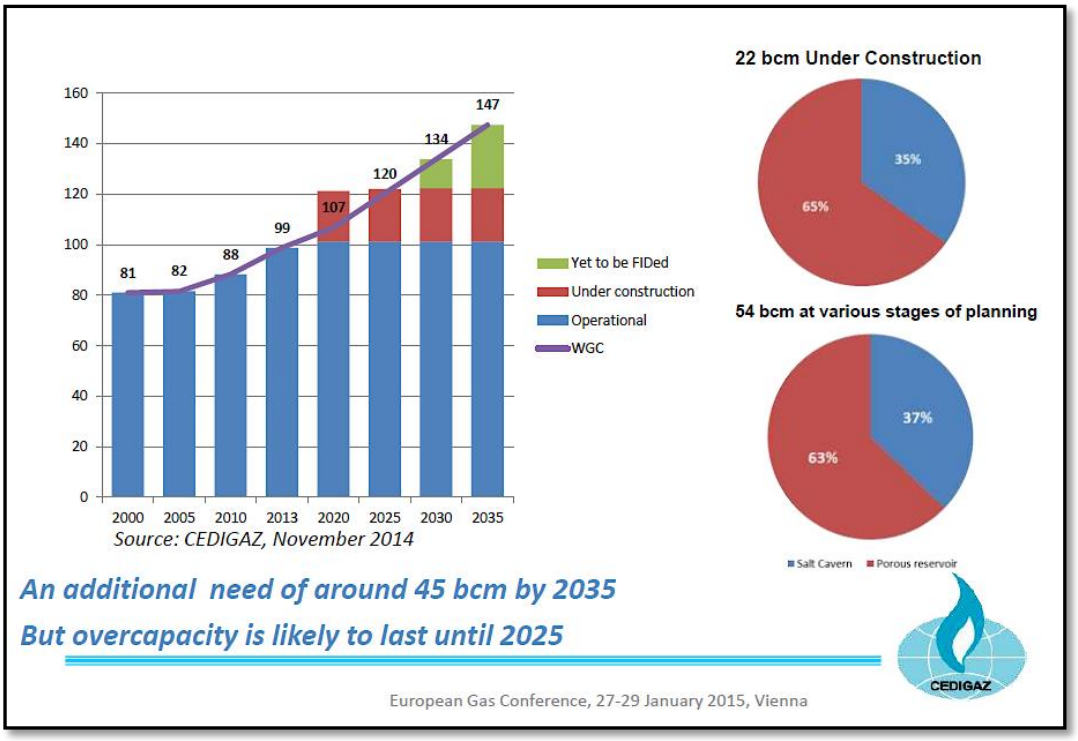

Figure 9: *European gas storage capacity*, Energy routes, 2015

According to the European legislation, each member state has to ensure that it owns enough capacity to supply its gas market for several months [16]. This legislation has been implemented in order to improve the security of supply of the EU and to allow the different member states to cover natural consumption during the winter months of peak demand. Usually, gas is injected into storage units during off-peak season, that is to say summer, in order to make stockpile of natural gas in a sufficient amount to cover the winter demand. That is the reason why the gas storage capacity is higher at the end of the summer than in winter, where it's unloaded.

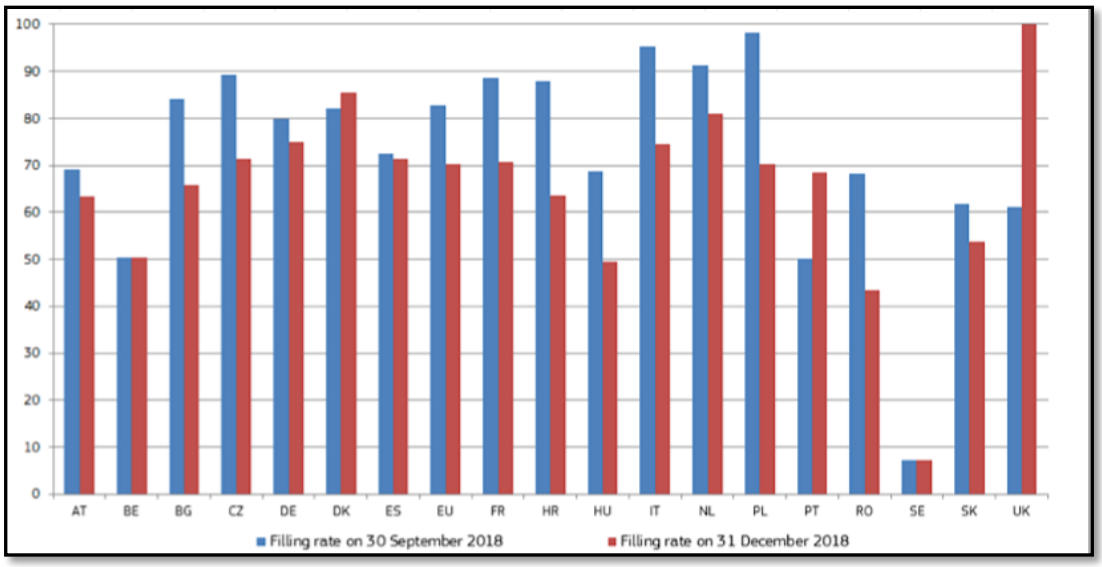

Figure 10: Gas storage levels as percentage of maximum gas storage capacity by Member State (Source: Gas Storage Europe AGSI)

Gas storage is key to Europe as it is a large net importer of natural gas. Building a strategic reserve of natural gas serves several interests, such as covering the demand, enhancing the energy security in Europe in case of a shortage and improving the resilience of each country in case of a shock, as each other Member State will be able to provide a portion of its own reserve to another one in need of natural gas.

That is also where interconnectors are important and play a key role in Europe for its own energy security and are used to achieve different objectives.

The European Commission proposed a goal of interconnections of 15% by 2030 among the different electricity and gas networks in Europe, to enhance the security of supply and facilitate the flow of gas or electricity within the member states [17]. In 2014 gas and electricity networks were only interconnected by 8% of the total in gas and electricity networks in Europe.

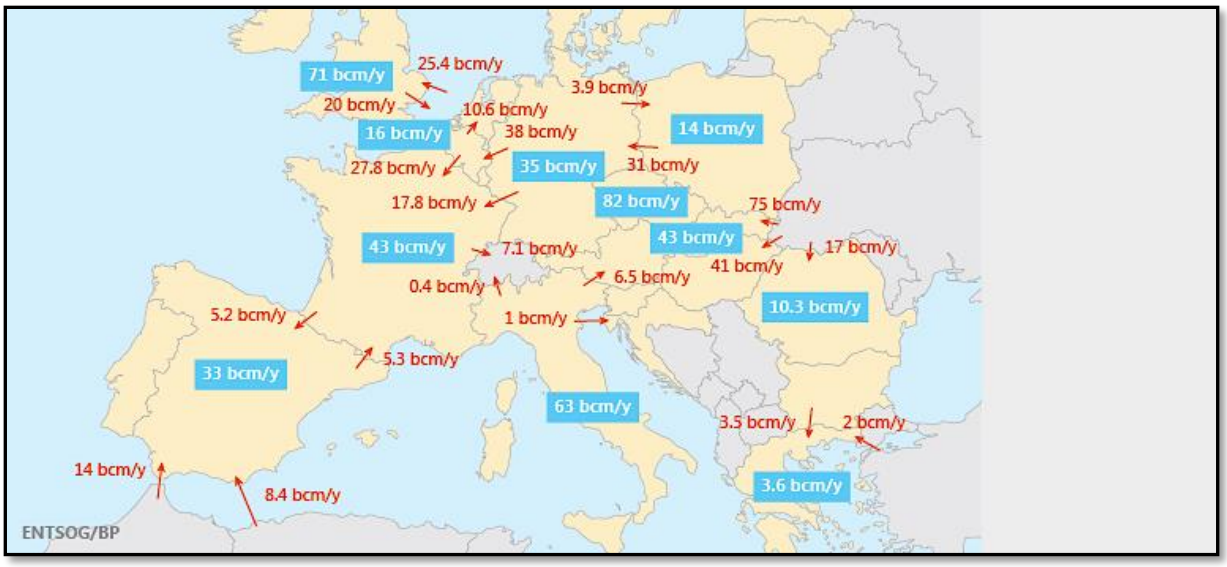

Figure 11: European interconnection capacity and annual demand for gas, 2014 (Source: ENTSOG; BP)

Interconnectors are useful thanks to their technical capability to deliver a reverse flow of natural gas. Most of the gas coming to Europe is coming from the East by pipelines to reach Western Europe where the biggest gas markets are located (Germany, UK, Netherlands, France or Italy), but if a country from eastern Europe needs gas because of a shortage or any unfortunate event, thanks to interconnectors, countries from Western Europe will be able to provide natural gas by inverting the flow of natural gas. This reverse flow can go from North to South and West to East and vice-versa [18]. Reverse flow is an achiever of the energy security, allowing countries with missing infrastructure links, long-term contracts with a single supplier (i.e. Russia) to have an escape route thanks to this natural gas solidarity initiated by the European Union.

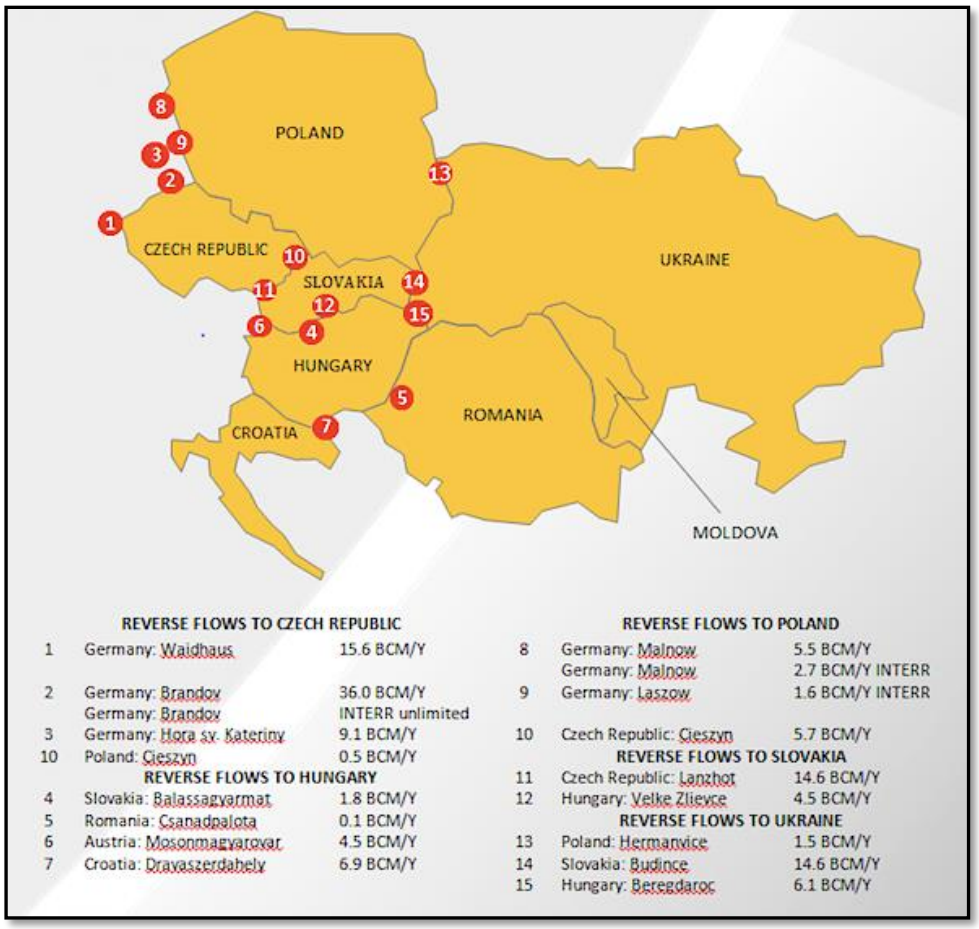

Figure 12: Central Eastern Europe reverse flow points, 2015 (Source: IPA industry Highlight)

Thanks to reverse flow, countries with a more developed gas infrastructure, that is to say storage and interconnections, can supply less endowed countries with their own reserves or they can use part of the gas supplied by another channel to send it through the gas network to another country. Figure 12 highlights these reverse flows: for example, Ukraine can be supplied by Poland, Slovakia and Hungary by a maximum of 22.2 bcm per year of natural gas. Knowing that 40% of the Russian gas supplied to the EU is passing by Ukraine shows how dependent Ukraine is from its Russian neighbor, whether it is for its own consumption or to receive fees for the transit of natural gas supplied to Europe [19]. Thanks to reverse flows, Ukraine can receive gas from other suppliers via neighboring states and reduce the influence of Russia on its gas network. Ukraine has consumed 32.3 bcm of natural gas in 2018 according to Naftogaz, the state-owned company, which means that reverse flows can supply 68% of the annual gas consumption from Ukraine.

Reverse flows allow distant market from the main gas hubs to be supplied in natural gas despite their proximity or dependency from a single supplier. These possibilities increase the resilience of EU28 but also from other European countries, not included in the bloc but interconnected with the European gas network.

1.1.5 Liquefied Natural Gas in the European Union

The natural gas market structure in Europe cannot be complete without including LNG in the equation. LNG has been, for a long time, a marginal option to supply the European gas market. On one side, this can be explained by the higher level of output from the domestic production and the long-term contract concluded with Russia to ensure the continuous flow of gas to the EU. On the other side, LNG development was not commercially viable compared to pipeline, the projects were expensive and took a long time of construction before being operational. But through the year, thanks to an improvement in the technology, new ways to finance projects and the development of the LNG fleet, the role of LNG has been reconsidered. As shown in figure 4, LNG imports accounted for 12,4% of the total gas imports of the EU in 2018 with 49.8 bcm, equivalent to a third of Russian gas imports. The global LNG imports grew by 19% in Europe over the last 2 years, showing the attractivity of this source of supply [20].

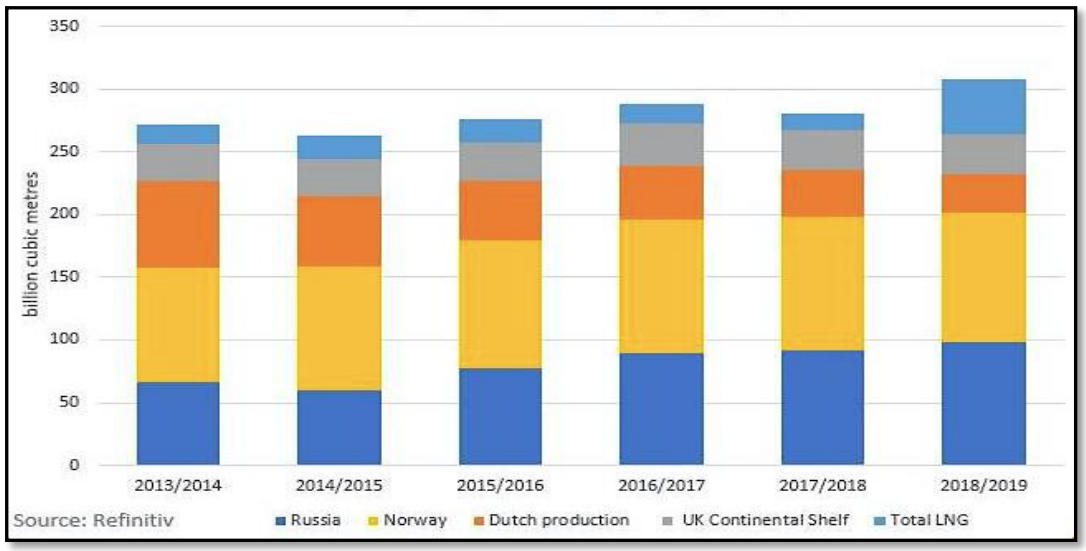

Figure 13: Total gas flows to the UK, France, the Netherlands, Belgium, Austria, the Czech Republic, Slovakia per gas year by source (Source: Refinitiv)

As LNG can only be transported by the sea, this market requires a specific infrastructure. On the supply side, liquefaction terminals have to be built to cool down the gas to turn it into a liquid. Then, LNG carriers will transport the liquefied gas and deliver it to the market. On the demand side, regasification terminals have to be built in order to take delivery of the gas before it can be sent in local pipelines for distributors and final consumers. The development of these infrastructures on both sides of the market is crucial to allow a sufficient flow of LNG to be shipped across the seas and have a real implication on the gas market.

In Europe, imports of LNG are coming from a various number of countries. As Figure 14 suggests, in February 2019, 22% of the total imports of LNG were coming from Russia, 20% from Qatar, 17% from Algeria and 17% from Nigeria and also 10% from the U.S. According to these numbers, Russia owns also a strong stake of the LNG market in Europe

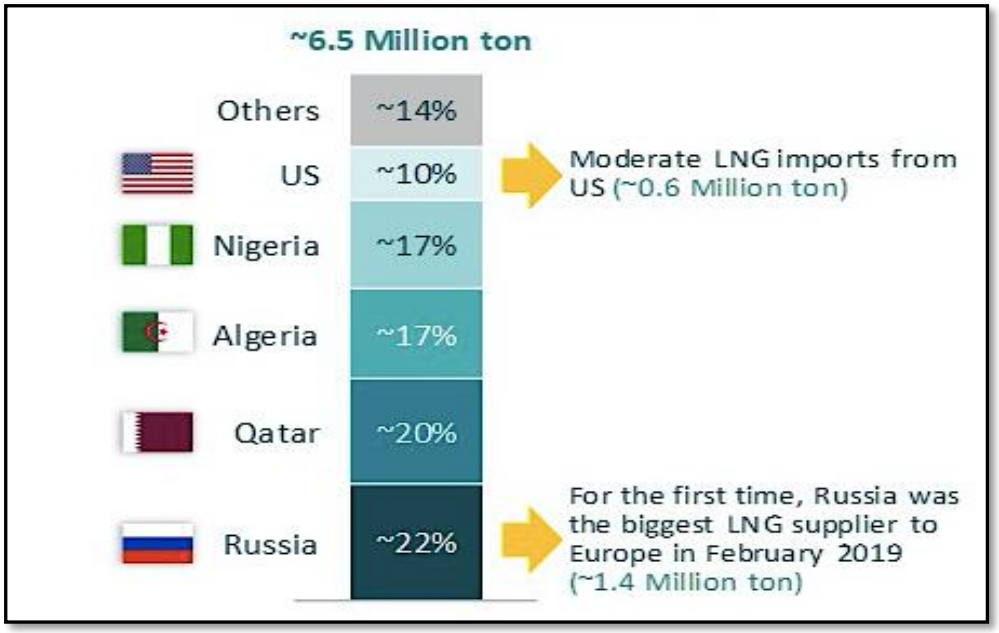

Figure 14: Indicative repartition of the European LNG imports by source in February 2019 (Source: ALSI, Reuters, Andalou, Emerton)

In 2018, 28 large-scale LNG terminals were operating alongside 8 small-scale LNG terminals in the EU, including non-EU Turkey. In 2017, the total regasification capacity of these large-scale LNG terminals only was 227 bcm of natural gas, enough to cover 40% of the European gas demand [21]. But in reality, LNG imports do not match that potential number of 227 bcm,

because the utilization of EU LNG import facilities has declined from 50% in 2010 to 20% and 25% in 2016 and 2017 as regasification capacity exceeds LNG imports according to the EIA. The relatively high prices from 2011 to 2014 led to a weaker consumption of natural gas for electric power generation but since then, a decrease in the price allowed the consumption of LNG to rise again since 2015.

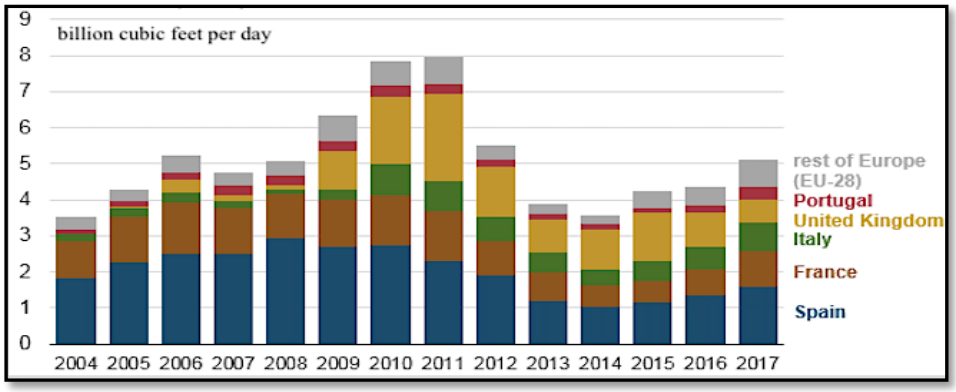

Figure 15: Europe liquefied natural gas imports, net of re-exports, 2004-2017 (Source: EIA)

In EU28, 24 large-scale terminals are currently operating, and many of them have an expansion planned, as Figure 14 shows above. As the EU is a main importer of natural gas, each member state with an access to the sea developed its own LNG infrastructure, with a support from the EU Commission and even some funding from the EU to increase the diversification of supply, which is multiplied thanks to LNG because it allows distant natural gas net exporter to have a step in the EU energy market. The different member states receiving LNG currently are Belgium with 1 terminal, France with 4 terminals, Greece with 1 terminal, Italy with 3 terminals, Lithuania with 1 terminal, Malta with 1 terminal, the Netherlands with 1 terminal, Poland with 1 terminal, Portugal with 1 terminal, Spain with 7 terminals and the UK with 3 terminals.

Figure 16: LNG Terminals in the EU, 2019 (Source: EU Commission)

The EU appeared to build a relatively diversified gas market and is trying to look for more diverse sources of supply thanks to LNG but is also enhancing the resilience of the bloc having regards to Russia with different mechanisms. An analysis of the Russian and of the U.S. gas sector should then follow to understand how the different actors built their strategy to have an access to the EU gas market and what would look like the future of the gas sector in Europe.

1.2 The Russian gas sector

Russia is one of the main producer, exporter and reserve holder concerning natural gas. According to the BP Statistical Review 2018, Russia has the largest proved reserves in natural gas globally, with 34.8 Trillion cubic meters while other countries such as Iran or Qatar have less resources, respectively with 33.2 and 24.9 Tcm of proved reserves. Russia is also the largest exporter of natural gas, with 251 bcm exported in 2018 [22]. But surprisingly, it is not the biggest producer of natural gas, the country is in second position as the U.S. is now the first producer of natural gas. In 2017, Russia produced 635.6 bcm of natural gas while the U.S. produced 734.5 bcm of natural gas, despite having only 8.7 Tcm in proved reserves.

1.2.1 Natural gas market in Russia

Russia is now the second largest producer of natural gas globally but has been the number one producer for decades before the U.S. surpassed the production capacity of Russia in 2011 by a vast amount (100 bcm of difference between the two countries in 2017).

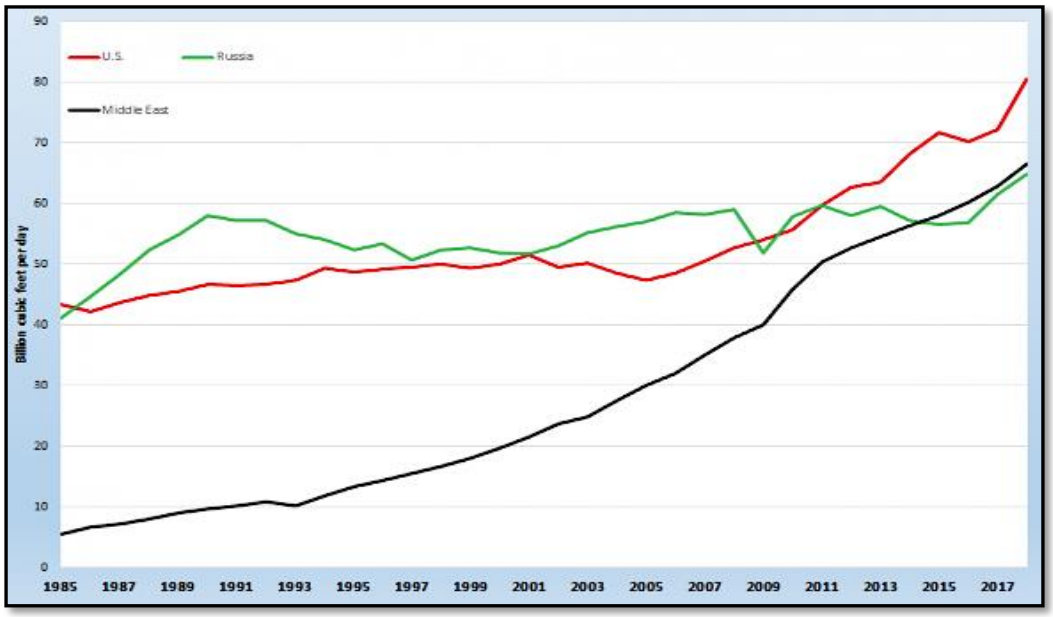

Figure 17: Natural gas production, 1985-2018 (Source: BP Statistical Review of World Energy, 2019)

Even if Russia is not the biggest producer of natural gas, it remains the largest exporter of natural gas. In 2018, Russia produced 669.5 bcm of natural gas and exported 251 bcm.

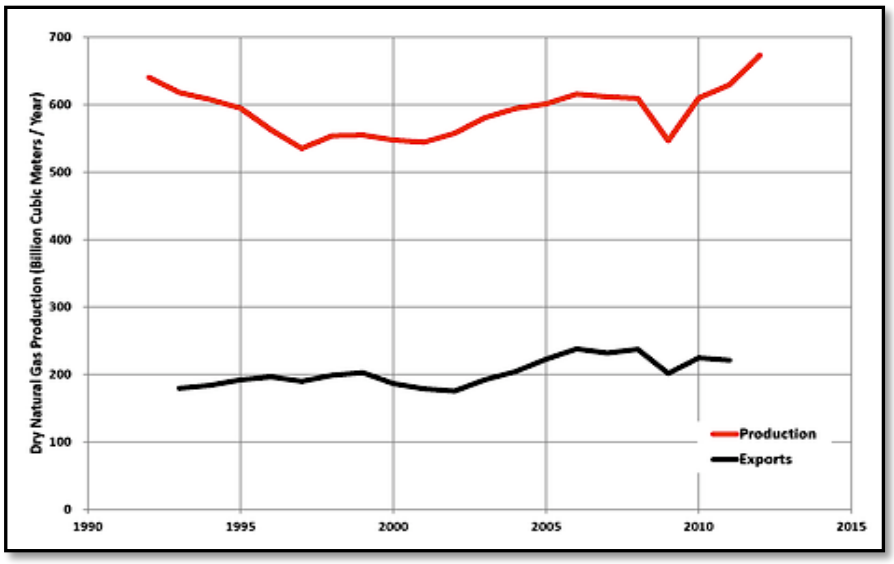

Figure 18 : Natural gas production and export in Russia
(Source: Graphed data from US EIA)

The wide difference between the production and the export of natural gas can be explained by the domestic consumption, accounting for 454.5 bcm in 2018 [23]. This result is slightly above the difference between production and export, which is 418.5 bcm, because Russia also imported natural gas for its own domestic market [24]. According to the EIA, 52% of Russia's primary energy consumption is made of natural gas. The country is the second biggest consumer of natural gas after the U.S.

The export capacity of Russia is mainly exploited by Gazprom, the state-owned company. In 2018, Gazprom supplied a total of 200.8 bcm of gas to European countries including Turkey, representing 80% of the total exports of Russian natural gas. As Gazprom is operating the vast network of pipeline from Russia to Europe, this allowed the company to gain market shares and is nearly, by itself, representing the core of the Russian export capacity. Russia is also delivering gas to Japan and is planning to supply India and China as well.

Figure 19: Main natural gas export pipelines from Russia (Source: CSS ETH Zurich)

Russia is mainly supplying gas via pipelines to its trade partners but is also ramping up its gas exports via LNG with large projects across the country. In 2018, the country exported 24.9 bcm of natural gas via its LNG liquefaction plants and is the 5th largest exporter of LNG after Qatar, Australia, Malaysia and the US [26]. The country is planning to invest in the development of its LNG export capacity to reach new markets and diversify its gas network.

Figure 20: LNG projects in Russia (Source: Wood Mackenzie)

Russia has already built and is planning the extension of mega LNG projects such as, Yamal LNG, which has a production capacity of 16.5 million tons of LNG per year, Sakhalin-2 with 9.6 million tons, Artic LNG-2 with 18 million tons, Shtokman LNG with 7.5 millions tons. Two other projects are under construction, with Far-East LNG with a capacity of 5 millions tons and Baltic LNG with a capacity of 10 million tons [27]. By 2022, thanks to the new projects, the LNG export capacity of Russia is supposed to double, being close to roughly 50 bcm.

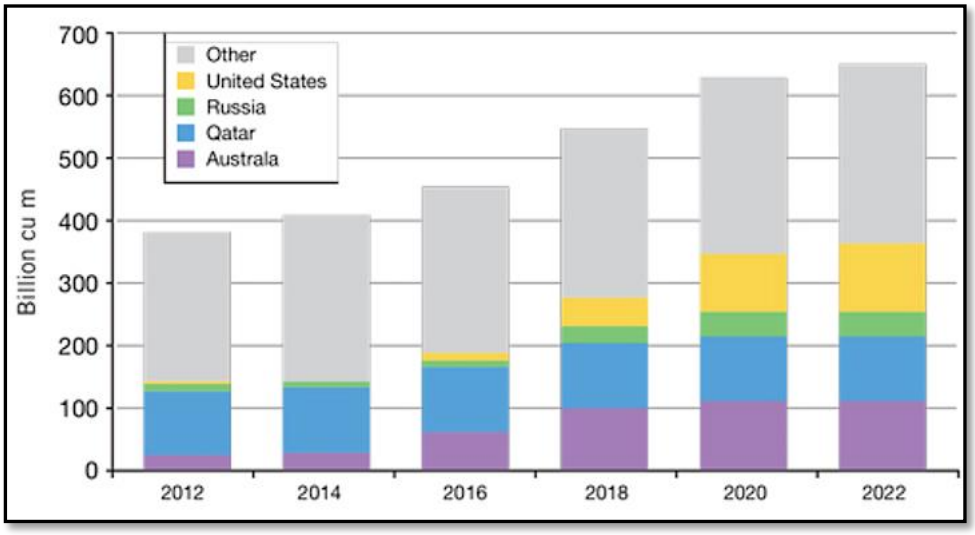

Figure 21: LNG export capacities (Source: International Energy Agency)

1.2.2 Natural gas supplies from Russia to Europe

Russia and Europe are naturally connected by their borders; this allowed Russia and the EU28 to build close ties having regard to the energy sector. The European Union is the main market for Russian gas as 40% of the gas consumption in the EU28 plus Turkey is coming from this country, its biggest supplier. Among the 40% delivered to Europe, 36.7% were supplied by Gazprom in 2018 with 200.8 bcm including Turkey and 176 bcm without [28]. Russia received $38.1 billion in 2017 for its total gas exports and the EU had an energy bill of 266 billion €, where 74.48 billion € accounted for natural gas imports [29], of which approximately 25 billion € were transferred to Russia as figure 22 shows. According to these data, 71% of the gas revenues in Russia are coming from the EU28, showing the great interdependency between the two partners, one requiring gas and the other currency to develop its own economy.

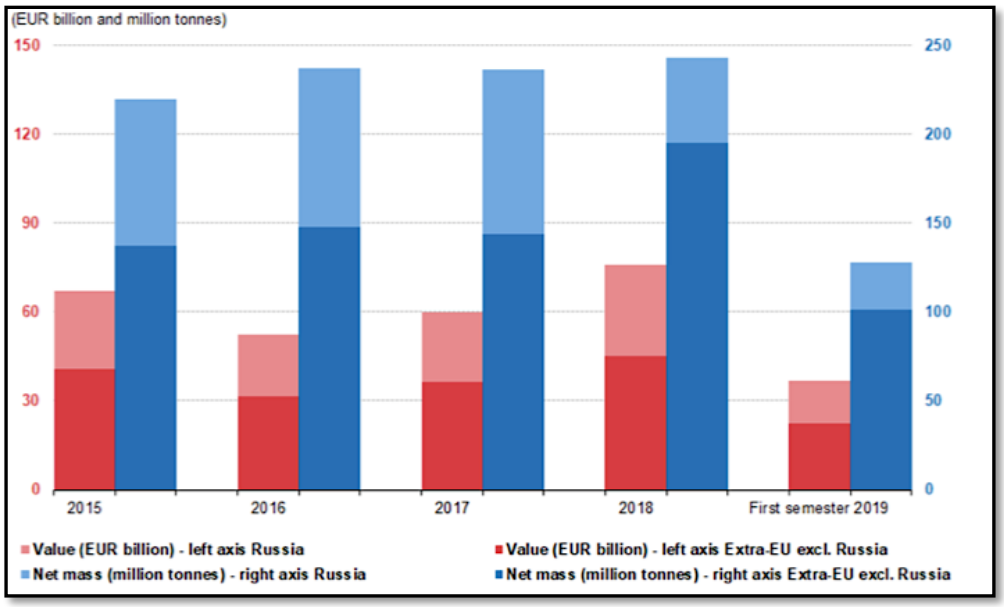

Figure 22: Extra-EU-28 imports of natural gas, 2015 – First semester of 2019 (Source: Eurostat)

Europe is key to Russia as it is a provider of foreign currency for a significant portion of the Russian gas production. Related to Figure 22 is Figure 23, indicating how Europe is central to Russia for its gas exports.

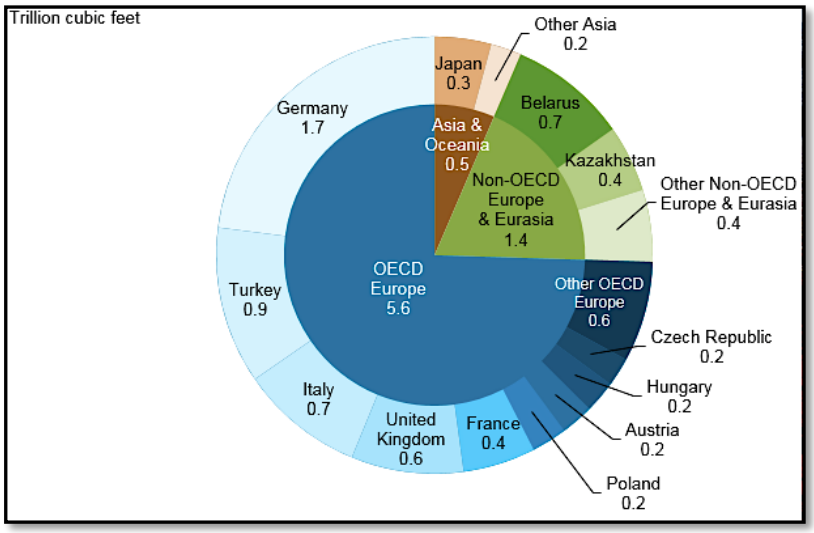

Figure 23: Russia natural gas exports by country, 2016 (Source: EIA)

In 2016, Russia exported in total 7.5 Tcf of natural gas to the market. 5.6 Tcf were supplied to OECD Europe, including Turkey, and 4.7 Tcf without. According to these numbers, 62,6% of the Russian natural gas exports were supplied to OECD Europe, without Turkey, in 2016. As Europe is the main consumer of Russian gas, it also means that European countries are strongly reliant on Russia for their domestic consumption. From the European side, relying mainly on a

single supplier could be a threat to energy security as it gives Russia a lot of influence and the possibility to threaten to cut the flow of gas to Europe without giving the EU a backdoor to look for other options. In 2006 and 2009, a gas crisis occurred between Russia and Ukraine, concerning a payment dispute between the two countries. Russia decided to cut off all the gas supplies flowing to Europe by Ukrainian pipelines. At that time, 80% of the Russian gas supplied to Europe was passing by Ukraine [30].

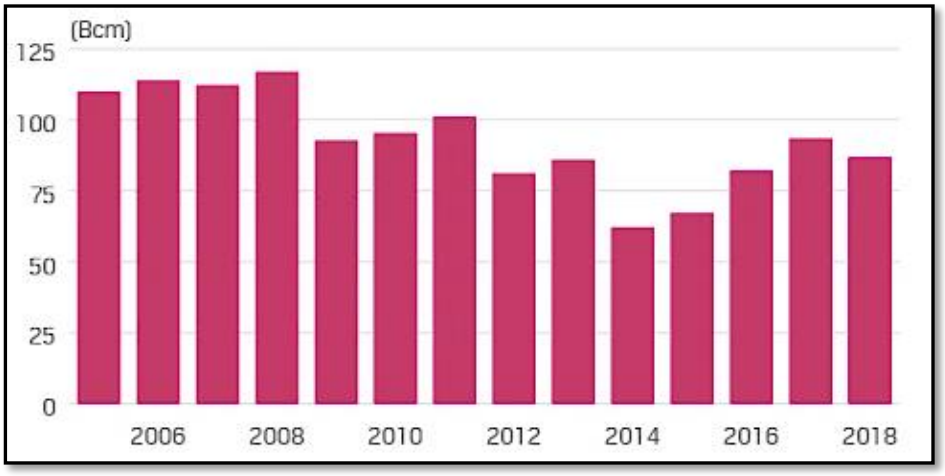

Figure 24: Russian gas transit via Ukraine dips in 2018 (Source: UkrTransGaz)

The share of Russian gas flowing to Europe via Ukraine was a strategic issue, as in 2006 and 2009, Europe imported approximately 200 bcm of natural gas each year and more than 50% of the total imports were passing by Ukraine. Things were very different in 2018, as the EU imported 400 bcm of natural gas, of which approximately 89 bcm passed by Ukraine, representing only 22% of the total gas flow coming from extra-EU imports. Furthermore, among the 176 bcm of natural gas that Russia supplied to Europe during that year, 89 bcm flowed by Ukraine to the EU, meaning that approximately 50% of the Russian gas passed by Ukraine in 2018. This trend depicts the will of European Institutions to diversify sources of supplies but also the different routes that natural gas has to take. A decade ago, Ukraine was a kind of systemic pillar for the EU concerning natural gas, as Russia was the main supplier and Ukraine the main state by which the Russian gas was flowing to Europe. Because of the

different shortages in 2006 and 2009, the EU decided to diversify the pipelines routes, in agreement with Russia.

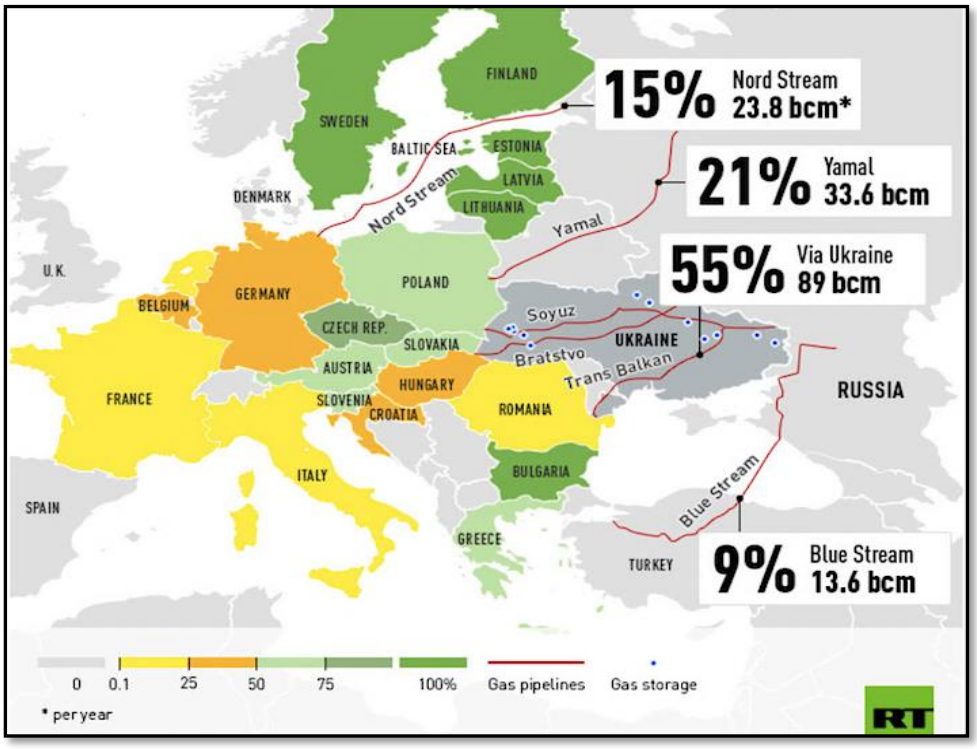

Figure 25: Russian gas to Europe, 2018 (Source: Reuters, EIA, Gas Infrastructure Europe)

Several pipeline projects have been built to reduce the share of Russian gas flowing by Ukraine and increased the energy security for the gas infrastructure. 45% of the gas in 2018 was supplied via different routes and other gas pipelines are supposed to be built in the future, such as the Nord Stream 2 pipeline, which is meant to deliver 55 bcm of natural gas each year to Europe according to Gazprom. This offshore pipeline will follow the original Nord Stream pipeline located in the Baltic Sea and is probably going to compete with the Ukrainian pipelines.

All these efforts to diversify the routes of supply coming from Russia are not changing the main issue for Europe, which is the stranglehold Russia has on its European neighbour concerning natural gas supplies. As Figure 25 and Figure 26 depict, 10 European countries are relying on Russian gas for 75 to 100% of their total imports and among them, 6 are 100% relying on Russian gas. These figures highlight the need for the EU to diversify significantly its sources of supply, to avoid any possible issues with Russia, as the latest has already cut off the gas

supplies in the past. The EU needs to find alternatives and new trade partners in the energy sector to diversify sufficiently its natural gas sources, to achieve stability in its own energy market. The U.S. could be a significant one, competing with Russia.

(share (%) of trade in value)

Country	Share (%) of Russia in national extra-EU-28 imports	
	Petroleum oils	Natural gas
Belgium	25-50	0-25
Bulgaria	50-75	75-100
Czechia	25-50	75-100
Denmark	0-25	0-25
Germany	25-50	50-75
Estonia	75-100	75-100
Ireland	0-25	0-25
Greece	0-25	50-75
Spain	0-25	0-25
France	0-25	25-50
Croatia	0-25	0-25
Italy	0-25	25-50
Cyprus	0-25	0-25
Latvia	0-25	75-100
Lithuania	75-100	50-75
Luxembourg	0-25	0-25
Hungary	50-75	75-100
Malta	0-25	0-25
Netherlands	25-50	25-50
Austria	0-25	75-100
Poland	50-75	50-75
Portugal	0-25	0-25
Romania	25-50	75-100
Slovenia	0-25	75-100
Slovakia	75-100	75-100
Finland	75-100	75-100
Sweden	25-50	25-50
United Kingdom	0-25	0-25

Table 1: Share of Russia in national extra-EU imports of each Member State, first semester 2019 (Source: Eurostat)

1.3 The gas sector in the U.S

The U.S. has been producing gas for a long time as production began around 1900. From this year until today, natural gas production has been rising to an all-time high in 2018, where the U.S. produced 831.8 bcm of natural gas in 2018 according to the BP Statistical Review of World Energy 2019 and are ranked as the number one producer of natural gas globally.

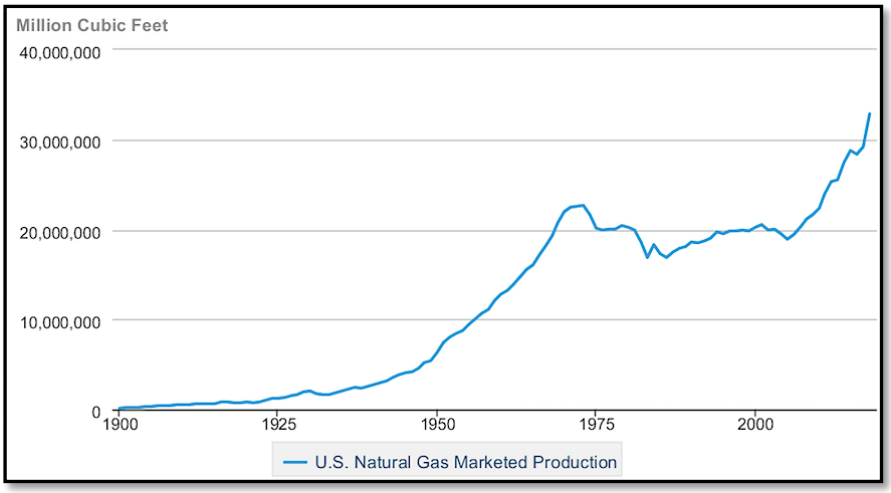

Figure 26: U.S. natural gas marketed production (Source: EIA)

Thanks to the shale gas revolution that occurred a decade ago in the U.S., the country has been able to ramp up its production, surpassing Iran and Russia as the top producers and this trend is set to continue.

1.3.1 Natural gas market in the U.S

Despite being the number one producer of natural gas, the U.S. is not considered as a main reserve holder nor a major exporter of natural gas. The U.S. only became a net exporter of natural gas very recently, in 2017 according to the EIA. Even if they produced 734.5 bcm of natural gas but consumed 739.5 bcm in 2017, the exports surpassed the imports. The domestic consumption of natural gas in the U.S. has been rising steadily and always surpassed the level of production until recently. Due to the large scale consumption of natural gas in the U.S., the country has not been able to become a net exporter until 2017. It's only thanks to horizontal

drilling and hydraulic fracking that the U.S. has been able to ramp up its production to cover most of its domestic production and then become a net exporter of natural gas.

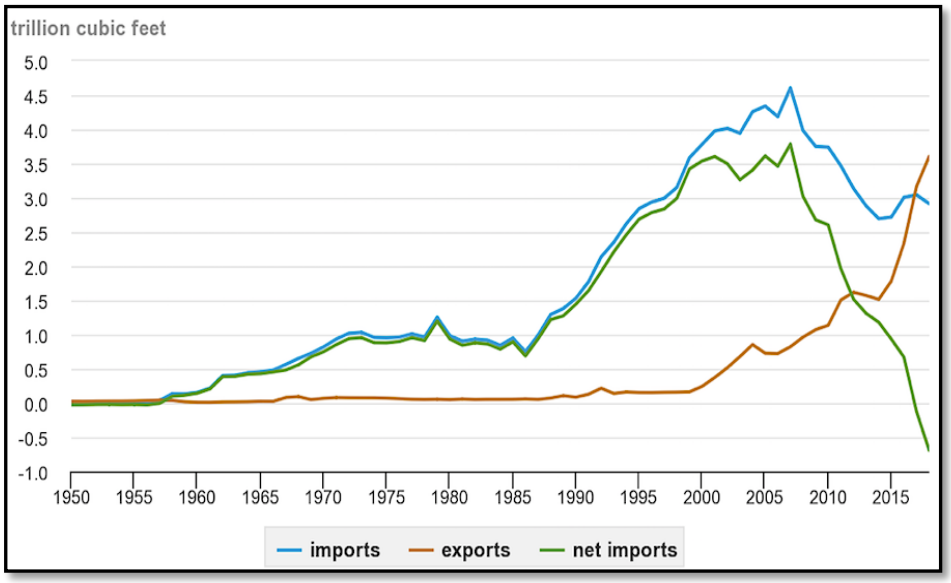

Figure 27: U.S. natural gas imports, exports and net imports, 1950 – 2018 (Source: EIA)

This uninterrupted growth in the domestic gas production in the U.S. is mainly coming from basins located in 5 states, where Texas is producing 22% of the total U.S. natural gas output, Pennsylvania 20%, Oklahoma 9%, Louisiana 9% and Ohio 8%. The net rise in production visible for the past decade is coming from shale gas, which accounts for 77.5% of the production of natural gas in the U.S. in 2018 [31].

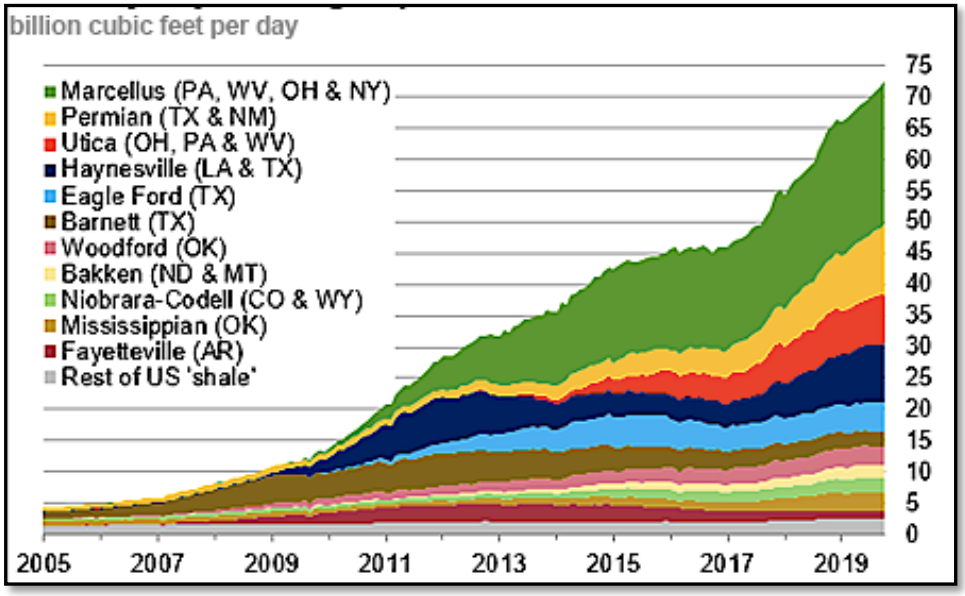

Figure 28: Monthly dry shale gas production (Source: EIA)

In 2018, the U.S. produced 831.8 bcm of natural gas versus 734.5 bcm in 2017, an increase of more than 13% in a single year while the consumption grew by 10% to reach 817.1 bcm in 2018 versus 739.4 bcm of natural gas in 2017. What is appearing according to the data from the EIA is that the gap between production and consumption is widening, followed by a similar path for the exports and imports of natural gas.

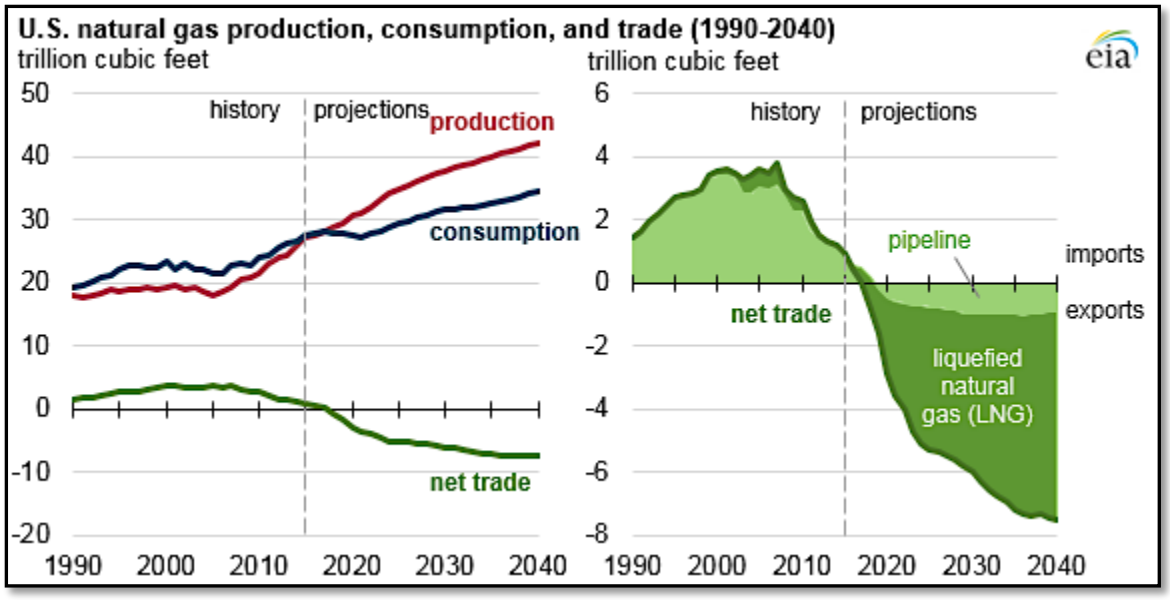

Figure 29: U.S. natural gas production, consumption, and trade, 1990-2040 (Source: EIA)

According to Figure 29, the net trade between production and consumption will continue to widen. Following this are the imports and exports of natural gas, where LNG will contribute to most of the natural gas exports, as pipelines are only connected to Mexico and Canada even if for now exports of natural gas by pipeline are superior in volume to the exports by LNG. For instance, in 2018, the total exports via pipeline to Mexico and Canada accounted for 2,524 Tcf while total exports via LNG accounted for 1,083 Tcf the same year. This means that 42% of the gas exports in the U.S. are made thanks to LNG while 58% are made with pipelines. Even if for now pipelines are the main infrastructure to exports natural gas, LNG is supposed to surpass the pipelines exports capacity as between 2016 and 2018, LNG exports grew by 570% whereas pipeline exports only grew by 17% [30].

When the U.S. shale boom began, the country was a net importer of natural gas and had to build many import facilities, mostly for LNG. Then, all the infrastructure had to go reverse due to the fast-paced rise in shale gas production in a short amount of time. Now the U.S. is investing into LNG liquefaction facilities, to export its gas. There are currently 6 American LNG exports terminals operating at the moment according to the Federal Energy Regulatory Commission (FERC), which are Kenai in Alaska (0.2 Bcf/day), Sabine in Louisiana (3.5 Bcf/day), Cove Point in Maryland (0.82 Bcf/day), Corpus Christi in Texas (1.44 Bcf/day), Hackberry in Louisiana (0.71 Bcf/day) and Elba Island in Georgia (0,035 Bcf/day). The total capacity of the operating export terminals is 68.97 bcm approximately for one year according to the theory and according to the FERC, in practice, its 51.67 bcm .

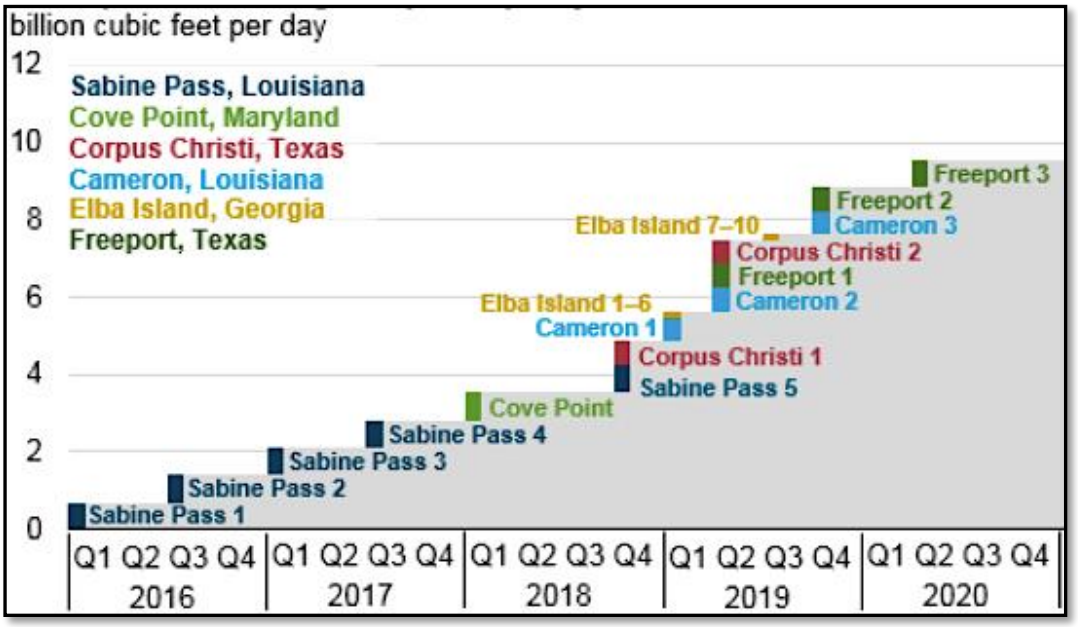

Figure 30: U.S. liquefied natural gas export capacity, 2016-2020
(Source: EIA, company investor presentations)

17 more exports terminals have been approved, 8 of them are under construction and the 9 remaining are not being built at the moment. 13 more export terminals have been proposed to the FERC and are under pending application or pre-filing. The activity in the LNG sector is surging in the U.S. and the exports are supposed to rise thanks to the additional capacity supposed to come on line within a few years. The International Energy Agency predicts that by

2024, U.S. LNG exports will reach 113 bcm, overtaking Qatar and Australia as the largest LNG supplier.

Figure 31: US LNG Projects and Current Status (Source: Company Reports, EIA, 2019)

1.3.2 Natural gas supplies from the U.S. to Europe

Trade relationships between the U.S. and Europe in the natural gas sector only began a few years ago, in April 2016, when Portugal received the first LNG shipment from Cheniere's Sabin Pass facility. The cargo delivered enough gas to supply the Portuguese market for a whole week [33]. Since then, natural gas supplies from the U.S. increased dramatically, by around 272% from April 2016 until July 2018; later on in March 2019, 1.4 bcm from American LNG have been supplied to Europe for this single month, the highest volume recorded among the two partners [34]. According to the European Commission, the U.S. is currently the 4th biggest exporter of LNG, with 28.4 bcm exported in 2018, and during the January-July 2019 period, 32% of U.S. LNG exports went to the EU. According to Figure 32 from the European Commission, American LNG could reach 13 bcm of natural gas supplied to the EU at the end of 2019.

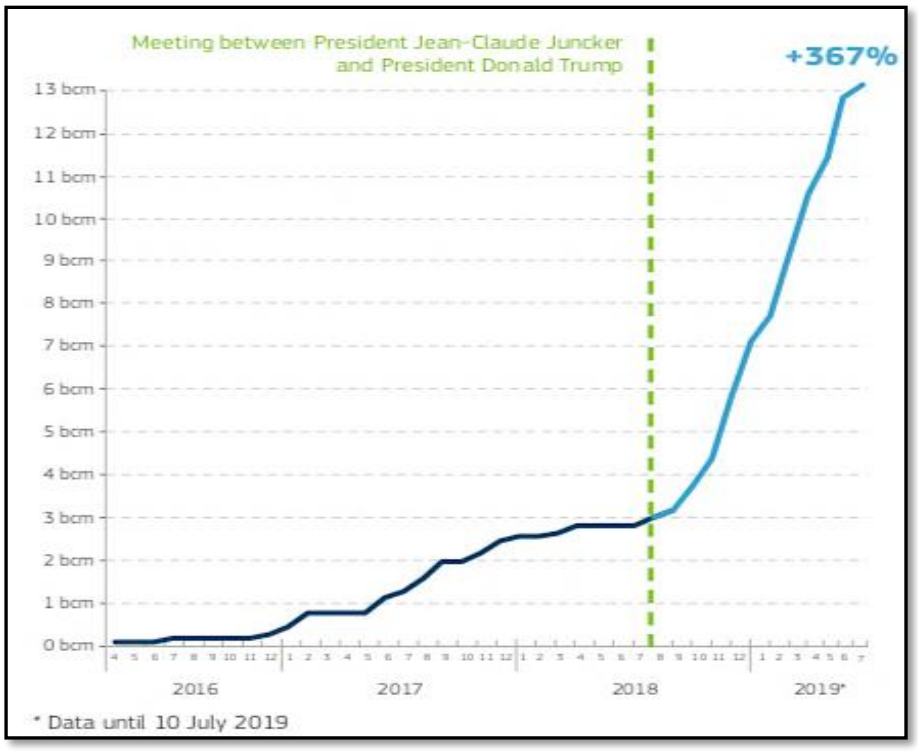

Figure 32: U.S. LNG exports to the EU are on the rise, in bcm – cumulative (Source: European Commission)

President Jean-Claude Juncker and President Donald Trump met in July 2018 to agree on an increase in LNG supplies from the U.S. to Europe and strengthen the trade relationships on that matter between the two blocs. Since the joint statement made by the two presidents, many more LNG vessels were shipped to Europe and are now totally integrated in the European gas mix.

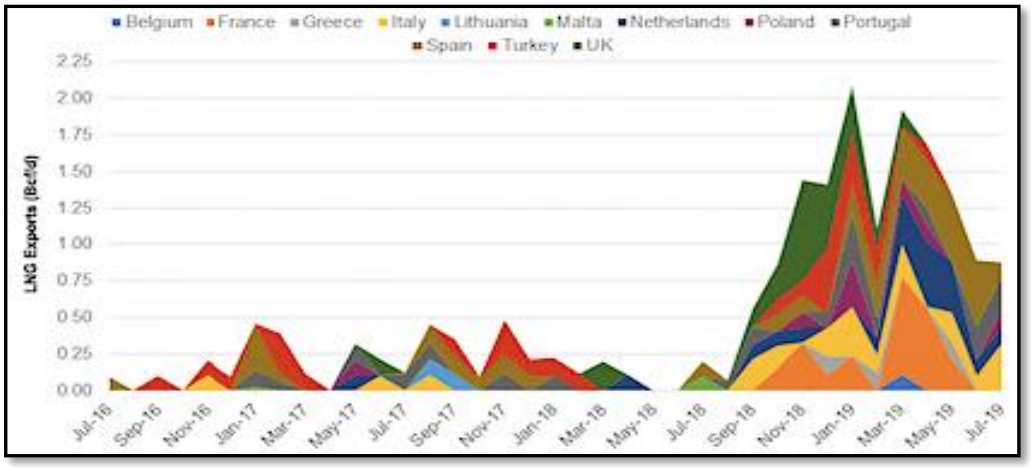

Figure 33: U.S. LNG Exports to EU Member States & Turkey, Jul 2016 – Jul 2019 (Source: EIA, NGI calculations)

According to the IEA, thanks to the new surge in LNG supplies from the U.S. in 2018, the EU saved $8 billion on its gas bill. As in 2018, natural gas accounted for 45% of total energy growth, mainly driven by the rapid expansion of the gas industry in the U.S. and the liberalization of the European energy market. This obliged Russia to change its oil-indexed pricing for natural gas and allowed its European partners to renegotiate the contracts [35]. As one can see, U.S. LNG has only appeared recently in the European energy landscape but it is already changing the established natural gas market. This trend is likely to continue as previously said: the International Energy Agency forecasted that the U.S. will become the first LNG exporter by 2024 in volumes.

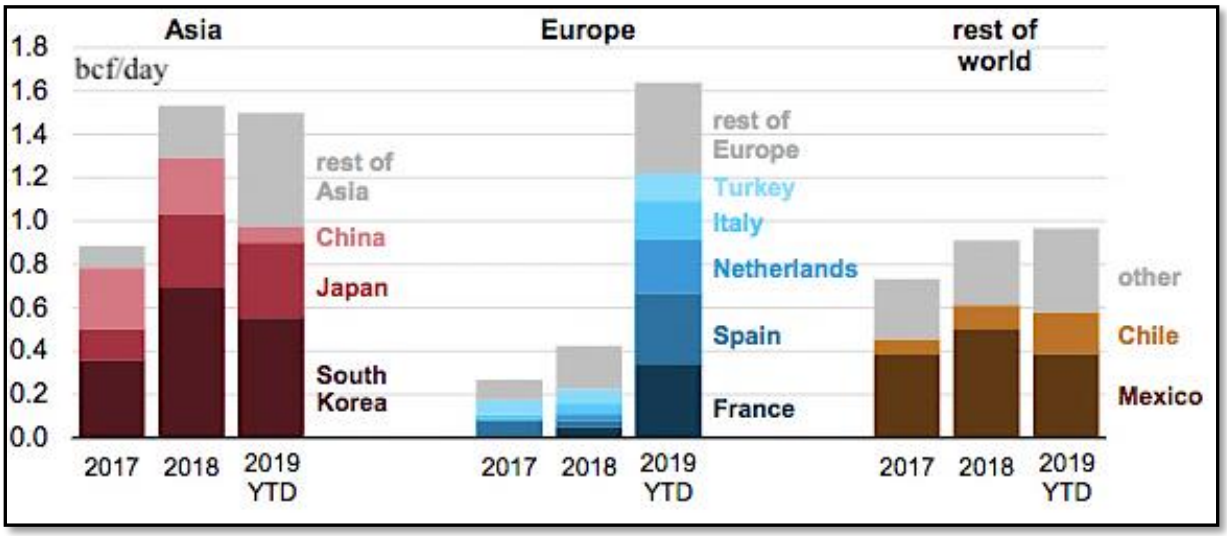

Figure 34: U.S. exports of liquefied natural gas, Janv 2017 – May 2019 (Source: EIA, Office of Fossil Energy)

What is also important to note, as shown in Figure 34, is that Europe became rapidly attractive for LNG supplies. In 2017 and 2018, most of the American LNG was shipped to Asia, as the prices for natural gas where higher compared to other markets. Since then, in 2019, US LNG shipment to Europe from January to May 2019 surpassed the ones for Asia. Many factors can explain this phenomenon, such as the demand and supply at a given moment, the liquidity of the gas market in Europe versus in Asia, the price of gas in each region but also geopolitical factors, such as the trade war between the U.S. and China, which resulted in a large diminution in LNG supplies from the US to China between 2018 and 2019. Also the competition between

natural gas in the power sector and other sources of energy to produce electricity such as renewables, nuclear and coal at some extent have to be taken into account, as well as the price of oil on a certain period. Hydrogen and biogas are other alternatives to natural gas even if their respective role is not highly significant for now.

As explained in this first chapter, the EU has an historical strong trade relationship with Russia concerning natural gas, as its own domestic production is declining at a fast rate. The U.S. is a newcomer in the gas export market and is ramping up its production capacity as well its exports facilities. Russia remains the largest exporter of natural gas but the U.S. is the biggest global producer of natural gas and is supposed to become the first exporter of LNG by 2024. The EU28 on its side is developing pipeline interconnection with Russia via Nord Stream 2 under construction currently but is also seeking other alternatives, whether by pipeline with other countries or by LNG with regasification capacity supposed to increase in the next coming years. As has been demonstrated, many agencies, institutions or consulting companies have been analyzing the gas market in the EU, in Russia or in the U.S. and provided forecasts, but none of them nor no particular author provided an analysis concerning the possibility for the U.S. to gain significant market shares in the European gas mix and eventually to challenge the status quo imposed by Russia on the European ground.

2. The future of the European gas market

To correctly understand if the US will once be able to challenge Russia having regards to its market shares in the European gas market, it is necessary first to analyze the future capacity for the EU to absorb a significant portion of gas coming from the U.S. in order to allow the country to gain market shares in Europe, as the natural gas from the U.S. will only consist in LNG shipment.

2.1. Future trend in the LNG import capacities of the European Union

Earlier in 2019, the European Commission published a document where the Commissioner for Energy and Climate, Miguel Arias Cañete said "(…) U.S. liquefied natural gas, if priced competitively, could play an increasing and strategic role in EU gas supply." This reflects the pledge made by President Juncker in July 2018 to buy more LNG from the U.S. To do so, the EU needs to develop its imports capacities sufficiently to welcome more natural gas in its liquefied form to allow the U.S. to become a significant player in Europe.

To determine what will be the future LNG regasification capacity of the EU, datasets are needed to provide a precise outlook of the gas import infrastructure of the bloc. Gas Infrastructure Europe is providing an official list of all the existing and future LNG plants meant to be completed until 2026 with the detail of the country of installation, if it is an EU28 or a non-EU28 country, the name of the installation, the status of the installation, the start-up year, the type of LNG infrastructure, the annual capacity in billion cubic meter of each regasification plant, the LNG storage capacity in cubic meters of LNG, the number of tanks and the ship class size each installation can receive. Thanks to this complete dataset, it is possible to analyze precisely what will likely be the outlook for the future LNG regasification capacity in Europe and build a detailed chart.

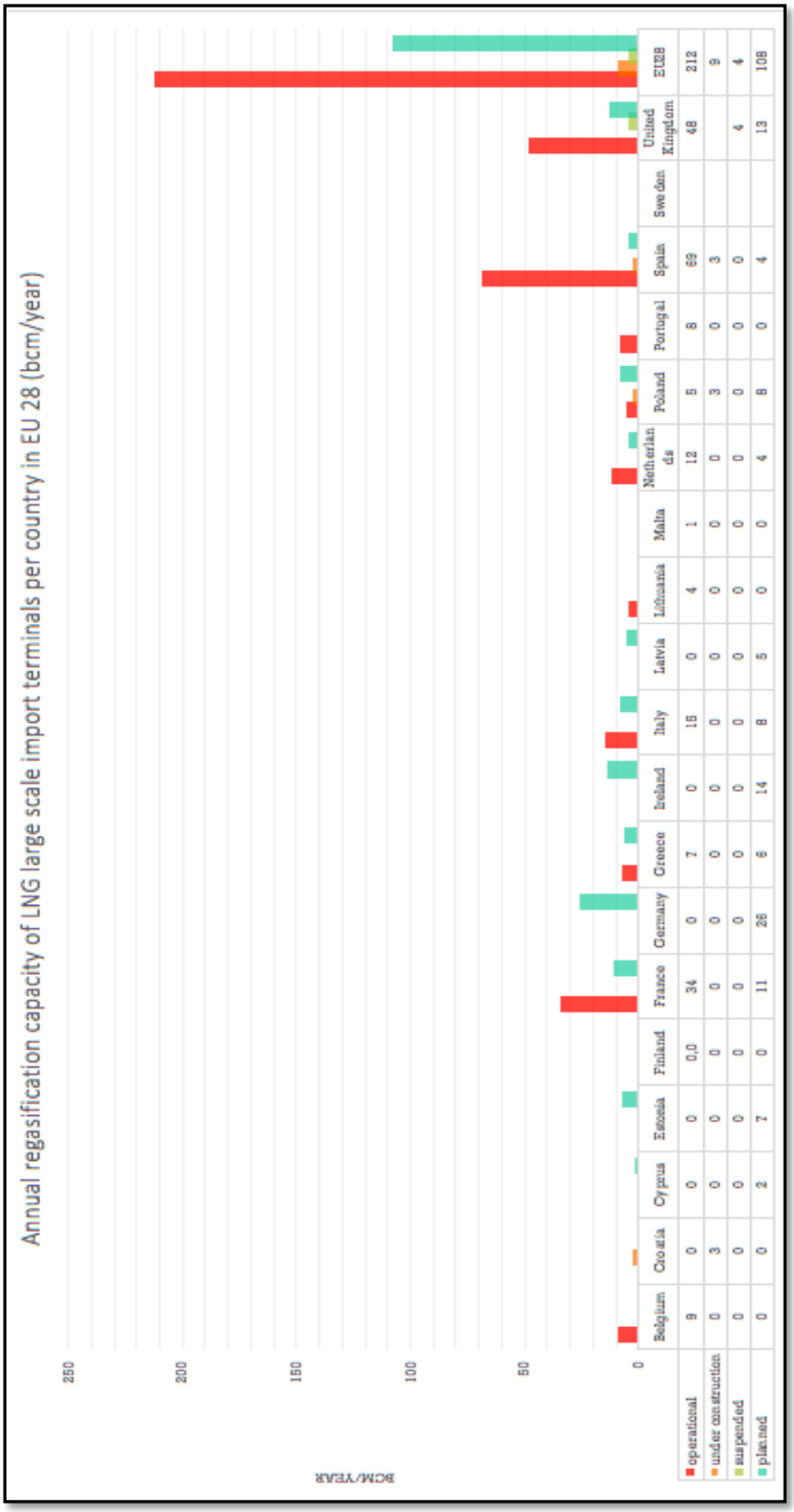

Figure 35: Expected annual regasification capacity of LNG large scale terminal by EU28 country (Source: Data collected on Gas Infrastructure Europe

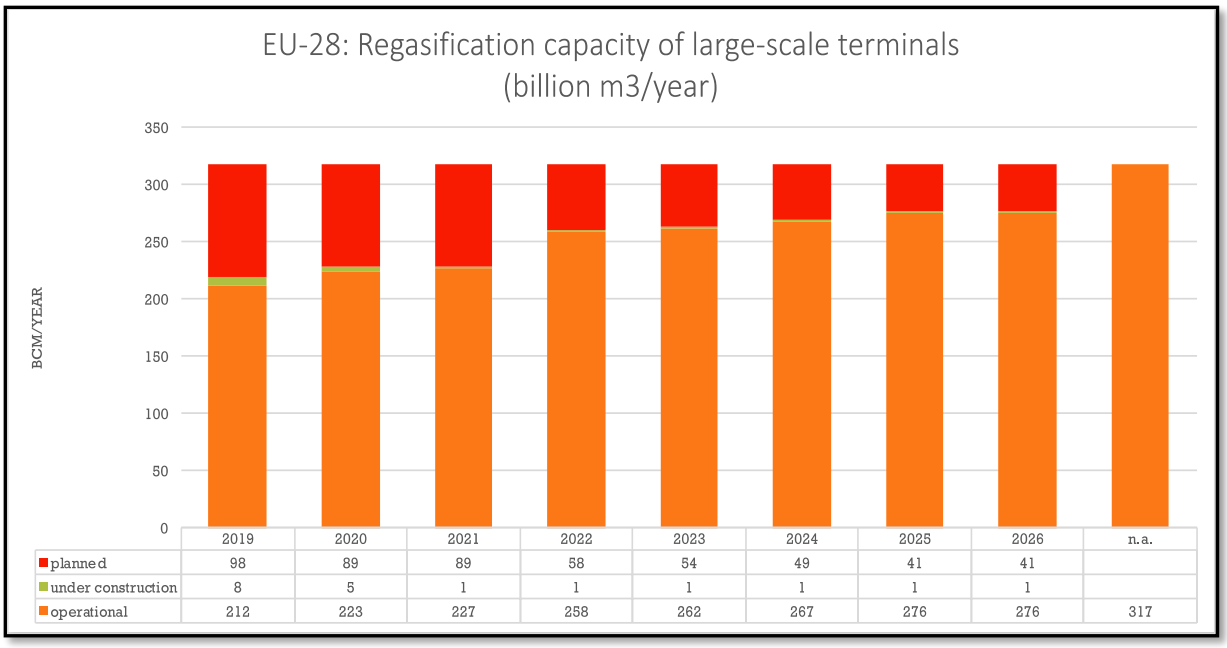

Figure 36: Total regasification capacity for LNG large-scale terminals in EU28, 2019 – 2026 and beyond (Source: Data collected on Gas Infrastructure Europe)

The two figures above suggest that the current operational LNG regasification capacity in EU28 for large-scale terminals in Europe is equivalent to 212 bcm per year in 2019 and that by 2026, the total capacity should reach 276 bcm per year, or an increase of 30% over the period. Beyond 2026, 317 bcm per year of total regasification capacity are supposed to be operational in EU28 in the long-term, having regards to the current knowledge of the projects undergoing.

The EU consumed on average 446.5 bcm per year of natural gas from 2011 until 2018 according to Statista. It means that theoretically, LNG could cover approximately 47.5% of the natural gas consumption of the EU28 in 2019, as the current regasification capacity is at 212 bcm per year. This percentage is only theoretical, because the utilization rate from regasification terminals is not 100%, but closer to 27% at the European level [36]. This means that the real level of LNG import is currently 57.24 bcm per year on average. Keeping this utilization rate of 27% for 2026 with a total operational potential regasification capacity of 276 bcm per year would mean that by 2026, the EU28 would import roughly 75 bcm per year of LNG, or an increase of 30% over the 2019 – 2026 period. It is also important to know what will likely be the future demand for natural gas in Europe. Many energy companies, consultancy companies

or institutions have developed their own scenario for the future gas demand in the EU28 and the results are widely diverse.

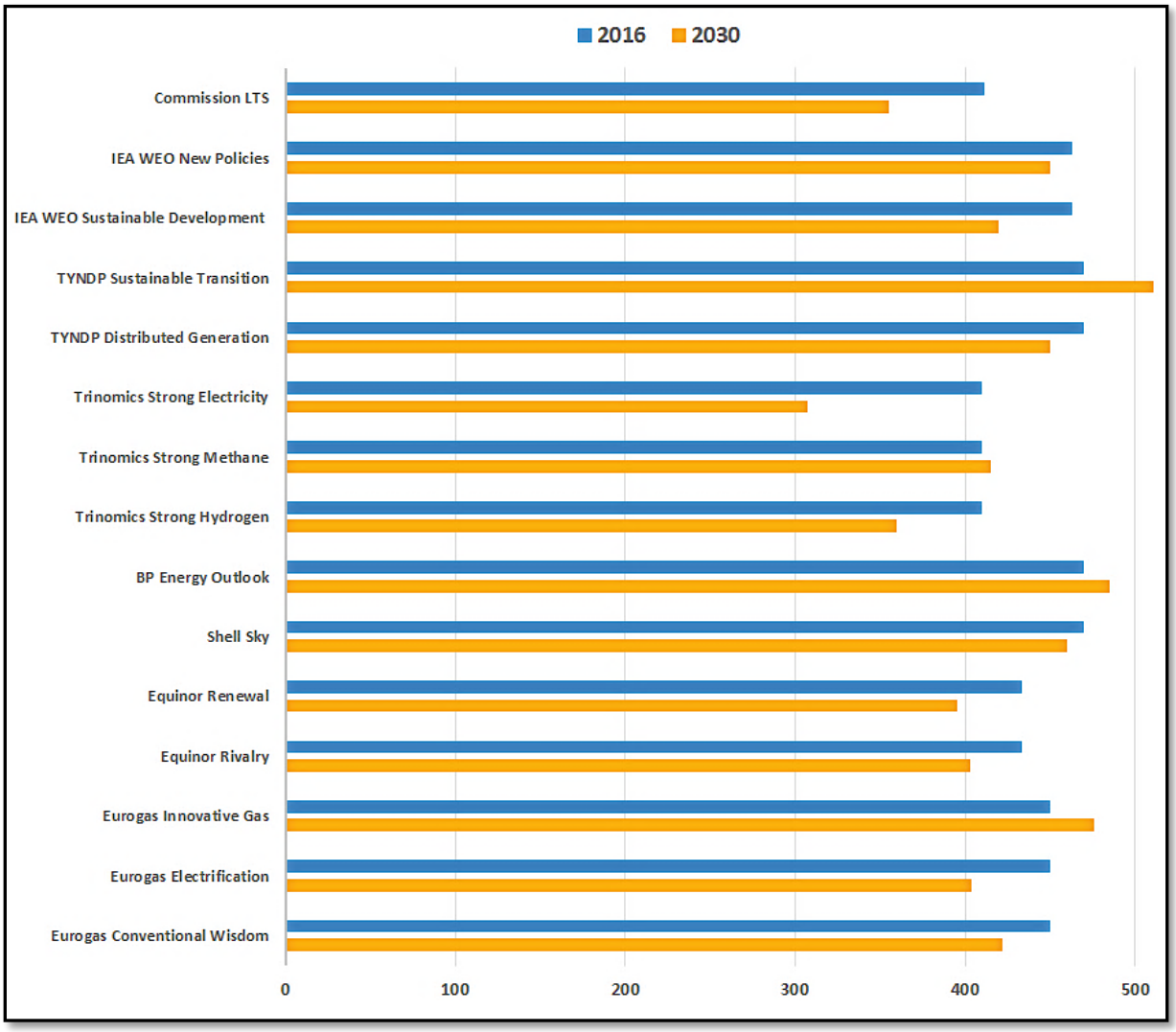

Figure 37: Projected gas demand for 2030 in Europe (bcm) (Source: EU Commissions – 2018, IEA – 2018, TYDNP – 2018, Trinomics -2018, BP – 2019, Shell – 2018, Equinor – 2018, Eurogas, 2018)

On the 15 different scenarios, only 4 suggest that the gas demand in 2030 will be higher than in 2016. This can be explained by different factors, such as a greater energy efficiency in the different sectors of the economy, requiring less energy to produce the same output. Also, the higher penetration of renewables and electricity storage in the power sector and the development of hydrogen and biogas should reduce the demand for fossil fuel such as oil and gas. The commitment of the EU to reduce CO2 emissions to meet the goal of the Paris agreement have to be taken into account to explain the reduction of the gas demand.

As a result, very different outcomes exist concerning the future demand curve of natural gas in EU, but 75% of the scenarios consider that the demand will be lower. A consultancy company, Aurora Energy Research, also projects that the demand for natural gas will be lower, but on the 2020 – 2040 period, with a decrease of 6% in the gas consumption over the period in Europe, passing from 459 bcm to 432 bcm [37].

Whether the gas consumption increase or decrease, it doesn't mean that the penetration of LNG in the European gas market can be jeopardized. A tighter market will imply a bigger competition among the different gas exporter countries, and one of the challenge to overcome for these exporters will concern the price at which they can sell their gas to the market. In that sense, if competitively priced, LNG can remain a real asset.

2.2. Future natural gas export capacity in Russia and the U.S.

Russia is currently the biggest gas exporter but the U.S. is supposed to become the first LNG exporter by 2024 in volumes. The rivalry between the two countries is real and should intensify through the year with the ramping up of U.S. LNG exports to Europe. Despite having bigger exports capacities, thanks to pipelines, Russia used to propose long-term contracts linked to the price of oil for its gas exports, whereas the U.S. managed to commoditize the LNG, bringing liquidity in this market and establishing a gas price index not related to the one of oil, to delink the two commodities and propose and attractive spot price for natural gas. That is an important point which can potentially help to push the U.S. exports of natural gas.

2.2.1 Future natural gas export capacity in Russia to Europe

Russia exported 176.3 bcm of natural gas in 2018 via pipelines to the European Union and 200.8 bcm including Turkey with the existing infrastructure. Nord Stream 2 is expected to deliver 55 bcm of natural gas each year to the European Union. Also, the Turkstream pipeline, developed by Gazprom, is supposed to deliver 31.5 bcm of natural gas to the Europe Union via Turkey. The two projects will not necessarily bring net additional capacity to the Russian gas exports to Europe, as it will be the occasion for Gazprom to decommission older pipelines, as announced in its optimization program. The company will reduce the capacity of the older pipelines passing by Ukraine to 10 to 15 bcm per year [38]. Russia is also building LNG facilities across the country, with most of it supposed to be shipped to Asian countries since the targeted countries for Russian LNG are India, Japan, China, South Korea, Kuwait and Taiwan. But some cargoes have also ended up in the European Union, so Russian LNG should also be taken into account for the future exports to Europe.

According to data made available by Gazprom in its deliveries statistics, PricewaterhouseCoopers, Reuters and Fitch Solutions, forecasts can be build, concerning the future pipeline capacity and the future LNG capacity of Russia.

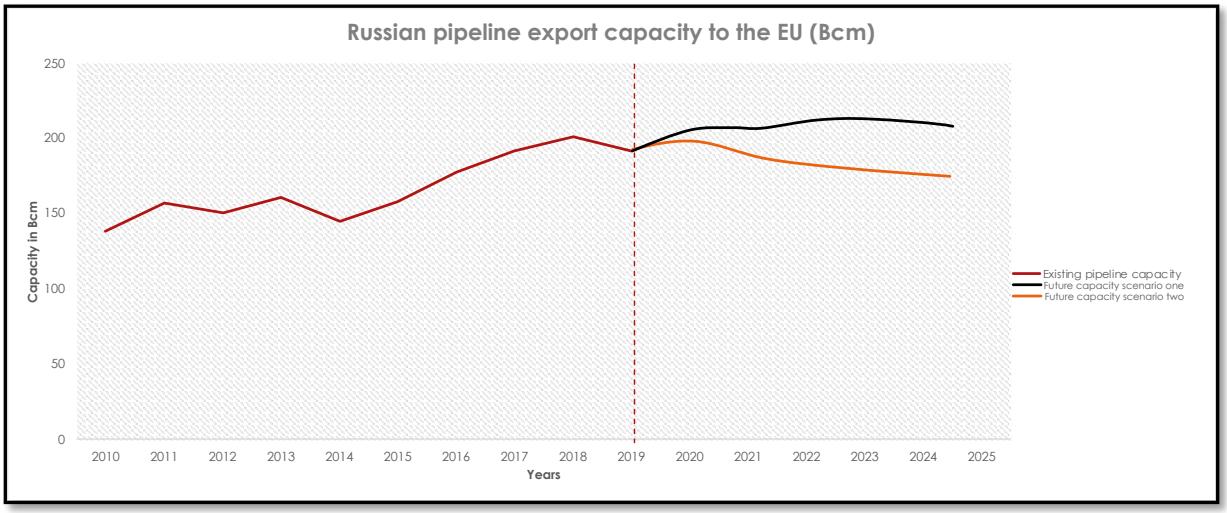

Figure 38: Projected Russian pipeline export capacity with a 2-factors scenario (Source: Data gathered from Gazprom, Reuters and Fitch Solutions)

Exports from Russia to Europe increased year on year since 2014 until 2018 where the exports declined slightly compared to a year earlier. For the years to come, two scenarios are considered. In the first scenario, Russian supplies by pipeline are increasing due to new pipelines projects in operations, bringing additional capacity, theoretically 86.5 bcm each year. In the same time, some old pipelines are decommissioned, such as some passing by Ukraine but the loss is immediately counterbalanced by new capacities. In that sense, Russian supplies will remain above 200 bcm of natural gas until the end of 2024 for the EU.

In the second scenario, despite additional capacity, drastic cuts in the existing delivery of natural through existing route, a more challenging environment for Russian gas exports due to American LNG and also new LNG facilities in Russia, export via pipeline may decrease slowly until 2024 to reach 170 to 175 bcm of natural gas. As Gazprom revealed in a document for investors in 2019, the utilization rate of the Nord Stream 1 pipeline is at an all-time high 107%. Also, the utilization rate for pipelines going through Ukraine is estimated at 65% but this number should decline as Russia is looking for new routes to deliver gas to Europe, creating a

new environment of uncertainty for the deliveries of gas, leading to a shortfall in supplies by pipeline. In addition, according to the IEA, around 100 bcm of natural gas contract are projected to expire by 2025 and will need to be covered. LNG is bringing more flexibility with shorter-term contracts, especially from the U.S. and the new pricing of natural gas in the country away from an oil-indexed price will be challenging for Russia to sign another long-term contract with European countries for pipeline deliveries.

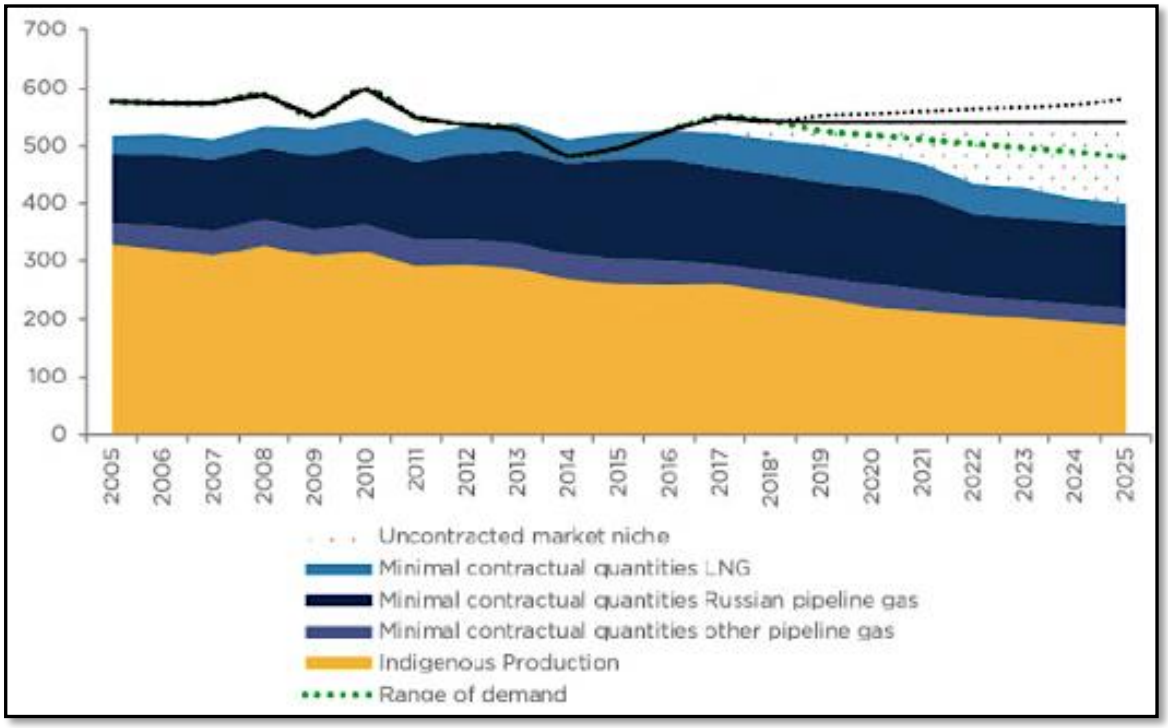

Figure 39: European Gas Balance, 2005 – 2025
(Source: Nexant WGM 2018, IEA Natural Gas Information 2017)

There is a significant uncontracted market which is supposed to widen to reach 100 bcm by 2025 to match the demand. Only the most competitive suppliers will be able to fill in the gap by proposing attractive prices.

Concerning LNG, the scenario is different, as Russia is not currently having many projects in operations and most of them are planned to be built in the next decade.

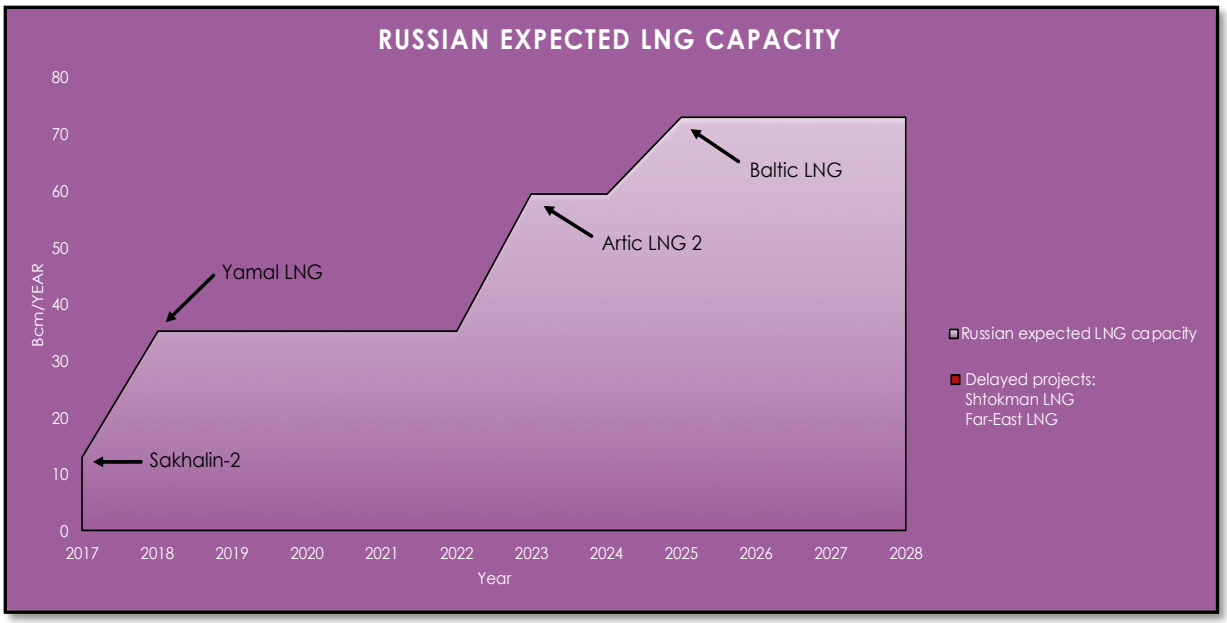

Figure 40: Expected future Russian LNG capacity (Source: Data extracted from PWC and Fitch Solutions)

With Sakhalin-2 and Yamal being fully operational, Russia has a theoretical export capacity of 35 bcm of LNG each year. Two significant projects, Artic LNG-2 and Baltic LNG are supposed to be completed by 2023 and 2025 respectively, bringing the total LNG export capacity of Russia to slightly above 70 bcm per year. Most of the LNG facilities built by Russia are supposed to deliver gas to Asia, where the biggest LNG importer are located, with Japan, China, South Corea and Taïwan representing the bulk of the imports in the region. Nonetheless, in February 2019, Yamal LNG delivered 1.9 bcm of natural gas via LNG to the EU, surpassing the exports made by U.S. LNG for that month [39]. This event proves that a new form of competition is rising in the LNG sector, as Russia is also looking to provide more flexible solutions to the gas market and deliver LNG. However, it is difficult to foresee how much of the future exports of Russian LNG will be supplied to Europe, due to a lack of data accessibility and also because Russia has been developing this sector very recently and has not yet created a financial environment such as in the U.S., alongside physical LNG deliveries. In addition, Europe is for now well supplied by pipelines from Russia, the country is currently targeting Asia to diversify its sources of exports.

2.2.2 Future natural gas export capacity in the U.S. to Europe

U.S. LNG only began to be shipped to Europe in 2016, but since then in a very short amount of time, this sector dramatically ramped up its export capacities. The total existing export capacity of LNG in the U.S. sits currently at 69 bcm per year according to data provided by the FERC. Nonetheless, the institution corrected that number to 50 bcm per year in operating capacity and the utilization rate is slightly above 50% with 28 bcm exported in 2019. Among them, 13 bcm of natural gas were shipped to the European Union.

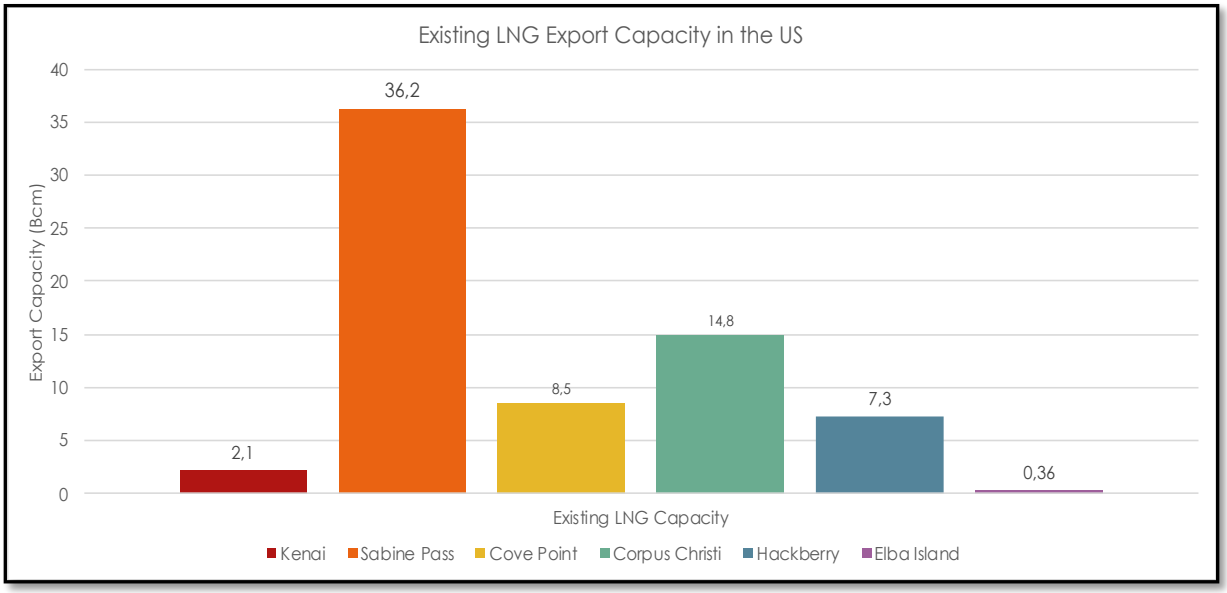

Figure 41: Existing LNG export capacity in the US, 2019 (Source: Data extracted from the EIA and the FER)

The U.S. is on track to become the leader in global LNG export by 2024 according to the IEA. To verify this assumption, data have been compiled and analyzed from the FERC and EIA websites, which are providing the estimated capacity of each future LNG project in the U.S. in bcf per day for each train. Thanks to a better data accessibility for U.S. LNG compared to Russia, a more precise forecast can be built concerning the potential for exports in that sector.

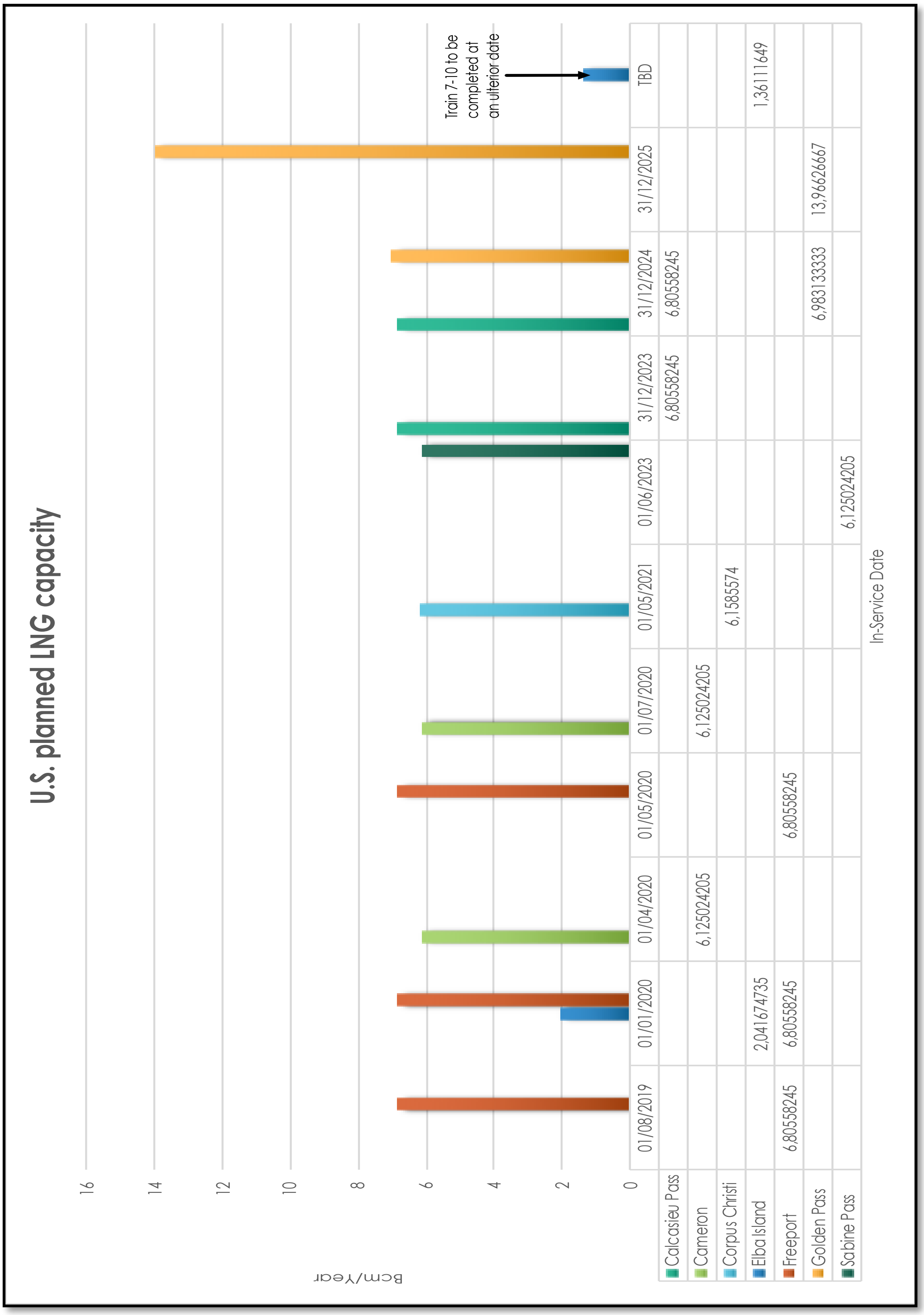

Figure 42: Estimated LNG capacity by 2025 (Source: Data analyzed from the FERC and EIA)

In the sheet presented in Figure 42, the future expected capacity for each project is given in bcm per year. Some projects are supposed to have different trains coming online at different in-service date, that is the reason why they appear in different years.

According to this figure, the Freeport project was commissioned in August 2019 and is supposed to deliver 6.8 bcm per year of LNG from train 1. It will also deliver an additional 6.8 bcm in January 2020 and the same number for May 2020. For Elba Island, train 1 to 6 are under commissioning and should deliver 2.04 bcm per year by January 2020, the trains 7 to 10 are supposed to be built but at an unknown in-service date, supposed to produce 1.36 bcm per year. The Cameron project Train 2 and 3 are respectively under commissioning and construction, with an estimated in-service date of April 2020 and July 2020 and should deliver 6.13 bcm per year each. The Corpus Christi project train 3 is under construction and should deliver 6.16 bcm per year from May 2021. The Sabine Pass project train 6 is under construction and should deliver 6.13 bcm per year from June 2023. The Calcasieu Pass project trains 1 to 5 and 6 to 10 are under construction and should deliver 6.81 bcm per year in each section, with an in-service date in 2023 and 2024. The last project is the Golden Pass one, with train 1, 2 and 3 supposed to deliver 6.98 bcm per year each, with an in-service date of 2024 for train 1 and 2025 for train 2 and 3.

The total expected liquefaction capacity for the U.S. by 2025 will be equivalent to 82.91 bcm per year. Adding the already existing capacity to that number will theoretically amount to 151.9 bcm per year. As the FERC corrected this number to slightly above 50 bcm per year for the existing liquefaction capacity, the result will be 133 bcm per year by 2025. The IEA's forecast was that the total liquefaction export capacity for the U.S. will reach 113 bcm by 2024. If the trains 2 and 3 from Golden pass are removed from the model, and the one from Elba Island with an unknown in-service date as well, the total planned LNG export capacity for the US in 2024 will amount to 117.68 bcm per year, close to the EIA number but still slightly above.

Having now the main forecasts concerning the future EU regasification capacity for LNG and the estimated amount of gas that both Russia and the U.S. are able to deliver, an assessment of

the prices of U.S. LNG versus Russian gas is necessary, as the price of natural gas is one of the main driver to evaluate the future potential purchases and quantity that the EU will consider to have the lowest gas bill possible.

2.2.3 Price comparison between U.S. LNG and Russian gas

This comparison is made to evaluate how competitive U.S. LNG can be against the bulk of Russian gas sent to Europe, mainly via pipeline. As for the future, cheapest gas options will be evaluated by the EU to reduce its gas bill from foreign suppliers. As it was said previously, some long term contracts are supposed to expire around 2024 and 2025, leaving a 100 bcm gap between the demand and the future supplies already contracted. This will happen exactly at the time when the U.S. is supposed to become the first LNG exporter.

The basic mechanism of the gas market, as for every commodity market, is that if the production and the supplies surpass the demand, the price of natural gas may fall sharply and the different players on the export side will have to reduce the price of the gas they sell to keep or gain market shares against other competitors or look for niche markets.

What the LNG sector brought compared to the pipeline sector is flexibility. As the gas is transported by ship, it can be transported wherever it is needed and the ship can change its route at almost every moment where the price of gas is the most attractive. This flexibility is not achievable by pipeline as it is a fixed infrastructure, but usually the cost of pipeline transportation is lower than for LNG and it takes less time to supply gas in the demand region. The U.S. shale boom allowed the U.S. to become the first producer of natural gas and also to become a significant player in the export capacities, leading to an oversupply of gas, and unlocked the commodity to become a major source of energy [40]. This has involved a dramatic fall in the price of natural gas as the chart below shows.

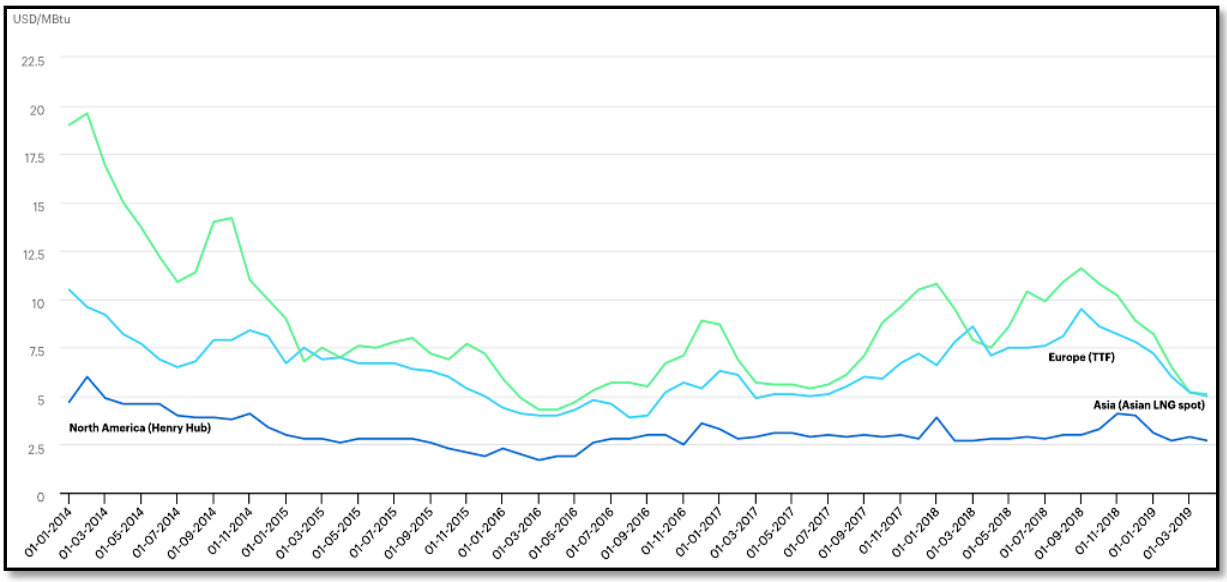

Figure 43: Evolution of natural gas spot market prices, 2014 – 2019 (Source: IEA)

On the figure, the spot price for Asia and Europe keep falling across the 5 years period mainly due to a surge of new LNG supplies. The Asian market was historically seen has the preferred market with a premium on the price of gas per Million British Thermal Unit (MMBtu) compared to the spot price for natural gas in Europe. But very recently in March 2019, the price from the two index converged around $5/Mbtu. In November 2019, the import spot price for natural gas in Europe was at $5.15/Mbtu and the Asian index fell to a similar level. This means that Europe is no longer a secondary market for LNG exporters, the supply is surpassing the demand, explaining why there is a global decrease in the LNG spot price in the demand region. Europe is paying less for its gas imports of LNG, as the price is fixed by a dedicated market and this is due to the shale boom in the U.S. As Russia used to fix the price of its gas in long term contracts indexed to oil, the country needs a new pricing strategy, otherwise, the steep decline in LNG price will imply a loss in its market shares. What is necessary to assess is the price per MMbtu with a Russian contract for gas versus the price per MMbtu for an American exporter and see at which threshold one or the other can sell its gas to the market while being profitable. It is already possible to foresee that the U.S. shale boom allowed to reduce the global average price of natural gas. What is interesting to see is how Russia managed to price its natural gas competitively to keep its dominance over Europe.

Figure 44: Gas contract price, Q1 2011 – Q1 2019 (Source: Equinor, World Bank, The Economist Intelligence)

Following the same trend than the European or Asian spot price, the Russian contract prices decreased as it used to be fixed by using oil prices as a proxy but since the shale boom, Russia had to change its pricing strategy to remain competitive against U.S LNG. Gazprom took the decision to discount the price of gas compared to oil and to include some spot price indexation. According to Alexander Medvedev, a Gazprom deputy chairman, the share of spot price indexation in Gazprom's export contracts reached 35% in October 2018. It means that the Russian contract price for natural gas is not entirely delinked from oil but this has already led to a reduction of the price for European countries. It is the reason why the IEA said that U.S. LNG helped Europe to reduce its gas bill by $8 billion in 2018, because of this pricing reform on Russian gas, which was necessary to implement due to the threat caused by U.S. LNG.

In parallel to the financial market and the price reform of natural gas, transportation costs should also be taken into account to understand the economics drivers in the gas sector.

Cheniere, one of the pioneer in U.S. LNG export reported on its website the price required per MMBtu to maintain profitability.

Europe LNG Sale Price ($/MMBtu)	$5.00	$6.00	$7.00	$8.00
Implied margin	$1.00	$2.00	$3.00	$4.00
Asia LNG Sale Price ($/MMBtu)	$7.00	$8.00	$9.00	$10.00
Implied margin	$2.00	$3.00	$4.00	$5.00

Figure 45: LNG Market prices profitable for Cheniere (Source: Cheniere)

As reported by Cheniere, even with a price of $5/MMBtu to supply LNG to Europe, the company is still profitable. Even more, by comparing Asian prices and European prices, the company has a margin of $2/MMBtu when the sale price is around $6 in Europe versus $7 in Asia. As European and Asian spot price converged towards $5, it will be more profitable for Cheniere to supply gas to Europe as the margin is higher. This reflects the capacity of the U.S. LNG industry to remain profitable even with very low spot price. The competition between pipeline and LNG is mainly established in the cost structure of transportation. The most competitive exporter in period of low prices for natural gas is likely to outperform. Several studies have been made to assess the price of LNG transportation versus pipeline.

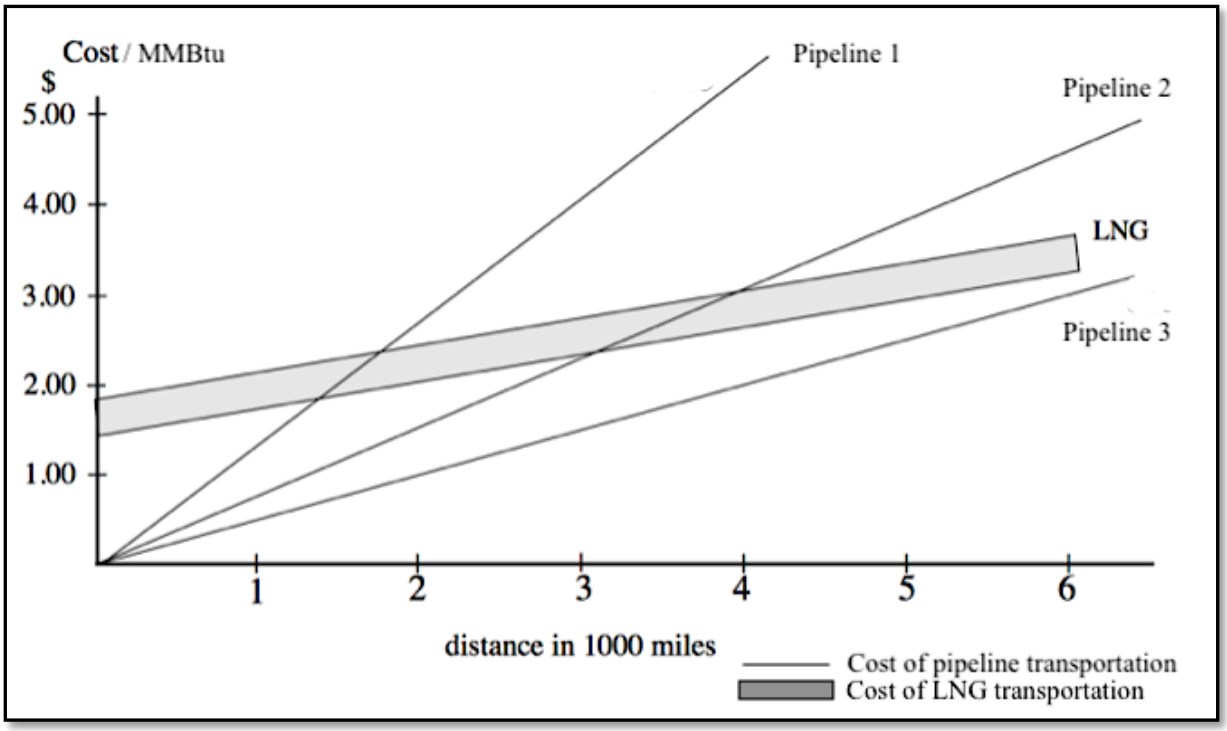

Figure 46: Cost comparison between LNG and pipeline transportation (Source: Gaille Energy)

The study made by Gaille Energy compares the cost to transport gas by LNG or by pipeline depending on the distance and the type of pipeline. The scenario 1 in Figure 45 concerns offshore pipeline, the scenario 2 concerns onshore gas under low pressure and the scenario 3 concerns onshore gas under high pressure. According to this study, the cost to transport LNG per thousand miles remains relatively low and the cost difference between a 1000 miles voyage and a 6000 miles voyage is in a close window of $1.80 to $3.30 per MMBtu. For pipeline, things are different as the cost depends of the type of pipeline to supply the natural gas. For instance, offshore gas pipeline remains competitive against LNG but only for a very short distance, around 1300 miles. Onshore gas pipeline under low pressure is more competitive against LNG, with up to 3000 miles of distance where the cost is inferior to LNG. The most competitive form of pipeline is the onshore one under high pressure, which remains competitive for more than 6000 miles with a lower cost than LNG.

American vessels leaving the coast of Texas or Louisiana to go to Europe have a minimum of 5550 nautical miles to travel, or 6386 miles, which means that the cost of transportation is approximately around $3.50 to $3.80 per MMBtu, in line with the Cheniere statement of $1 of margin per MMBtu when the contract sale price in Europe is at $5.

For Russia, which mainly has gas pipeline to supply Europe, the dynamics are different. The country has one offshore pipeline, Nord Stream and is currently building Nord stream 2 to supply Europe. Nord stream is 759 miles long and has an annual capacity of 55 bcm. Nord Stream 2 has the same characteristics. As the two offshore pipelines are short-distance ones, they are cost competitive against U.S. LNG and they have a high capacity. The planned offshore pipeline Turkstream is 677 miles long with a 31.5 bcm of annual capacity and seems competitive against U.S. LNG. What should also be taken into account for all offshore gas pipelines are the different inland onshore pipeline necessary to deliver the gas to the offshore

pipeline from the supplier side and then the different onshore pipeline on the consumer side to deliver the gas in the different regions. This represent an additional cost.

Yamal gas pipeline is 2500 miles long approximately with a 33 bcm of annual capacity. Whether it's a high or low pressure onshore gas pipeline, it remains competitive against U.S. LNG according to Figure 45.

Russia seems to have an overall lower cost to transport natural gas to Europe thanks to its vast pipeline network and the high level of export capacity. But U.S. LNG has successfully decreased its costs to remain profitable even with low natural gas spot prices. Also, the new pricing dynamic initiated by the U.S. drove the global price down and increased the competition between Russia and the U.S. over the European gas market, an argument supporter by CNBC in an article published in January 2019 entitled "Europe is fast-becoming a natural gas battleground for Russia and the U.S."

2.3. Scenarios for the future natural gas market in Europe

From what has been analyzed, it seems that Russia and the U.S. are on track to become the two biggest competitors in the European gas market. This will have implications for the future shape of the European gas market. With all the data previously exposed, models can be designed. Each model, from an economic point of view should take into account different parameters. Obviously, the future regasification capacity and pipeline capacity within the European Union and future export capacities from Russia and the U.S. are keys to design realistic assumptions. Also, what should not be forgotten is the declining output of European gas fields as well as Norwegian gas fields, which will leave more room for other suppliers to fill in the gap. The cost to carry natural gas is crucial for competitiveness and attract the demand of natural gas from the supply side. Other factors have to be taken into account such as the utilization rate for liquefaction and regasification facilities for LNG, as well the utilization rate from Russian pipelines. The supposed declining demand of natural gas in Europe over the long-term is also likely to drive price down and quantities required to historical low and this will force the suppliers to achieve cost discipline and to propose attractive price.

In the price analysis section, it has been seen that at current low prices, European spot price is more attractive for U.S. LNG than the Asian one, but in case of a tighter market with higher spot price, Asia will be more attractive and will be seen again as a premium market for U.S. LNG, which can potentially deviate LNG vessels from Europe to Asia and reduce the market share of U.S. LNG in Europe. So two different outcomes seem to appear, one with a global lower spot price for natural gas and one with a higher global spot price.

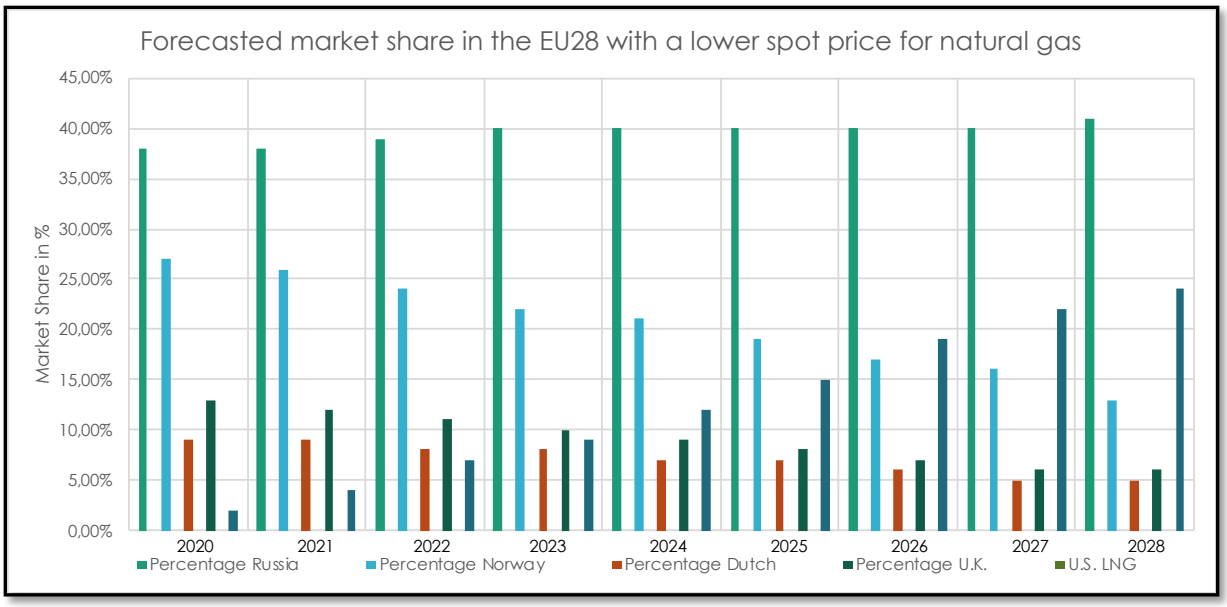

Figure 47: Forecasted market share in Europe with a lower spot price for natural gas (Source: Resources used in the thesis)

In the case of a longstanding low spot price for natural gas, the assumption here is that Russia will keep its lion's share in the European gas market but it will be counterbalanced by a steep increase in U.S. LNG export as the country is supposed to reach a superior export capacity in 2024 compared to others LNG producers and exporters. The Netherlands, UK and Norway in each of the scenarios lose market share as their production is decreasing either with a low or a high spot price. LNG vessels from the U.S. will logically deliver gas to Europe as the margin is higher compared to Asia in period of low prices and among the 5 producers in the chart, the U.S. will have a market share of 25% in the European gas market by 2028. Of course, this model does not take into account other potential suppliers for Europe such as Algeria, Qatar, Nigeria, … because the main objective of this thesis is to assess if the U.S. can challenge Russian gas in the long-term to reduce the Russian markets shares in the European gas market and provide more stability, affordability and energy security in the gas sector. UK, the Netherlands and Norway are taken into account because they are still important suppliers to the EU but it is already known that their national production is doomed to decline over time, and this will leave room for other suppliers, mainly Russia and the U.S., because they have the reserves, production, export capacity and financial leverage to compete against each other and

oust the potential remaining suppliers. It does not mean that only the U.S. and Russia will remain in the European market, but more that they will account for most of the shares.

So for the input in the model, the market shares are distributed according to the level of current and future production and export capacity of each member. The market shares are given at the EU28 level and not only between the 5 countries one against another, even if the total of their supply to Europe is equivalent to 89%, the 11% remaining are distributed between various LNG producers, Algeria and Libya.

From 2020 to 2028, Russian market shares in the EU28 should grow from 38% to 41% in the lower spot price scenario. It is a small but consistent increase, due to new pipelines and potential LNG projects delivering gas to Europe. This slow rate of increase is counterbalanced by the surge of U.S. LNG flowing to the EU28 region. From a 2% market share in the EU28 in 2020, U.S. LNG could potentially rise to a 24% market share in the European gas market by 2028, due to a longstanding low spot price, many liquefaction facilities becoming operational by 2024 and additional projects supposed to be built between 2024 and 2028. The declining gas production from European countries will mainly be replaced by U.S. LNG, thanks to its competitiveness and the arbitrage between Asian and European markets that U.S. LNG producers can take, preferring the eurozone in period of low spot price. Russia will keep its leading position as a supplier but the U.S. will be able to expand significantly and build a strong position in the European gas market. The benefits for the European Union are diverse, from a lower gas bill thanks to the new pricing competition between the suppliers to an increasing energy security. Having a supplier able to supply gas to Europe in large quantities in case of a shortage of gas coming from a new potential dispute between Ukraine and Russia or directly between the EU28 and Russia or other events such as a natural disaster or an outage in the gas infrastructure is an asset. In that kind of scenario, the low utilization rate for European utilization terminals will make possible to receive more LNG supplies in significant quantities

and interconnections between the European countries will allow LNG to flow by inter-member States pipelines and to reach finally eastern Europe, enhancing solidarity between the Member States. If the U.S. are able to export up to 113 to 120 bcm by 2024 and more in the years after, according to the model in figure 46, they will be able to deliver up to 90 to 100 bcm of natural gas to the EU, which will cover approximately 24% of the European consumption of natural gas per year by 2028.

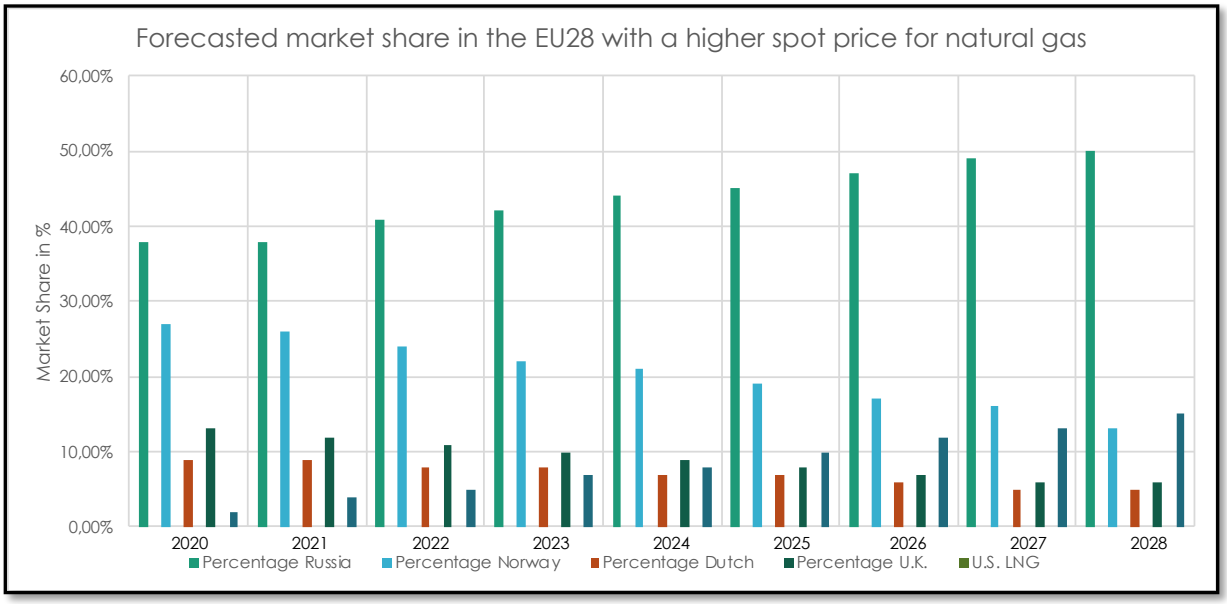

Figure 48: Forecasted market share in Europe with a higher spot price for natural gas (Source: Resources used in the thesis)

In the case of a longstanding higher spot price for natural gas, things will be different within the European gas market. The declining production from Norway, the Netherlands and the UK will not change as the gas fields are ageing and the price of natural gas will not have an influence over their market share in Europe. The U.S. will prefer to ship most of its LNG to Asia in that case, due to more favorable market conditions and a higher margin for LNG suppliers, that will reduce their market share in Europe. As Figure 47 exposes, the markets shares for U.S. LNG will grow from 2% in 2020 to 15% by 2028. The U.S. will still be able to build a comfortable position in the European gas market by 2028 but they will not be able to counterbalance Russian gas, as explained in the previous scenario. The European gas market will be seen as a secondary market from a U.S. point of view and the Asian one as a premium market, more favorable to

U.S. LNG producers. This situation will benefit Russia, which will have more power negotiation with European countries, leaving less room for the Member States to diversify their sources of supply. Russia will be able to increase the utilization rate of its pipelines and probably extend some long term contracts that are due to expire by 2024. Also, as Russian LNG is preferably intended for the Asian market, it will have to compete with U.S. LNG in a period of a higher spot price, but the Asian market is larger than the European one and the consumption of natural gas in the Asian region is increasing at a fast rate compared to Europe, which has stabilized its level of consumption. In that sense, some LNG vessels will still be shipped to Europe from Russia but not in significant numbers, because it makes more sense for Russia to use the pipeline at a higher utilization rate for Europe and sell LNG to Asia on the other side. According to the model, Russian market shares in Europe will grow from 38% in 2020 up to 50% by 2028, which is not at the benefit of Europe. Less competitors and a growing Russian influence will leave Europe more dependent to Russian supplies and the European gas market will be less secure in case of an issue. The U.S. will not fully play their role of secondary reliable supplier in that scenario. Even if more pipelines will deliver gas to Europe from Russia, via offshore and onshore pipelines passing by different routes, Russia will be able to reinforce its positions in the European market and will have more negotiation power and can increase the pressure on European states, especially the ones relying 100% on Russian gas supplies or close to its border. In case of an issue, it will be harder for Europe to increase the utilization rate of its regasification facilities and of its interconnection infrastructure to deliver gas to Eastern Europe.

The results as exposed were followed by the implications that each scenario can bring to the European Union, Russian and the U.S. and what they imply for the future of the global gas market. It is now necessary to discuss the limitations and the significance of the findings.

3. Discussion concerning the findings

This chapter concludes the thesis and provide a deeper understanding concerning the results of this research.. As the data for the European Union, Russia and the U.S. concerning the future are mainly theoretical and provided by different players in the gas sector, the data in practice may not be the same and this potential discrepancy needs to be discussed. Also, some other elements, not related to the economic field and the gas market, will have an influence over the future shape of the gas sector and can modify the forecasted results. Ultimately, the significance of the findings should provide an answer over the research question and implications for real-world practice.

3.1 Limitations concerning the findings

Overall, the historical data used for the existing gas market and its evolution until today are accurate, coming from renowned institutions or company such as the International Energy Agency, the Energy Information Administration, the Federal Energy Regulatory Commission, Eurostat, the European Commission, the statistical review of energy by BP or other energy companies or consulting firms. Some data were given in different units of measure and needed to be converted into a single one, the billion cubic meter, for a better understanding of the volumes and to make comparisons between different suppliers or between the demand side and the supply side. Some companies don't have exactly the same data concerning the level of consumption within the EU and the distribution of the market shares among the different suppliers of natural gas, but for most of the big figures such as the EU production, consumption and imports, the data are coming from renowned institutions and are accurate. For some more precise data, such as the cost of transportation for LNG versus pipeline, the data are coming from research papers or consulting firms and may not reflect the precise reality or are different depending on the supplier. Also, data concerning the European Union and the U.S. for LNG

are more precise and accurate than the Russian ones because official institutions are providing all the data set as reported by the companies or countries concerned, which gives a greater precision for the results. Concerning Russia, some data are provided by Gazprom such as the level of Russian exports or the pipelines projects, their capacity and utilization rate but concerning the future LNG capacity in Russia, data came from PricewaterhouseCoopers. All the assumptions made for the future shape of the gas market in Europe and the market shares of each player are coming from this findings previously explained. Depending on their degree of precision, the models built will be more or less robust and reflect the reality of the market in the future. Official data from a Russian institution would have made the results stronger and probably more relevant as they are directly given by the State. The lack of data accessibility on the Russian side made the research a bit more difficult and challenging compared to the EU or the U.S., highlighting the need for Russia to create its own energy agency, covering and providing data for the Russian energy sector, as the Ministry of Energy of Russian Federation is not proposing data and report such as Eurostat or the EIA use to do.

In addition, this study covered existing and future trend in the gas market between the EU, Russia and the U.S. mainly from an economic point of view, to explain what are the drivers shaping the market. But other factors are also influencing the gas market even if they are not directly related to the demand or the supply. For instance, the EU28 made a strong commitment to build a greener eurozone and to reduce its CO2 emissions to net zero by 2050, as Ursula Von Der Leyen, the new president of the European Commission, unveiled recently. Greener policies have implications for the fossil fuels produced or imported to Europe. According to this statement, what should logically follow is a decline in fossil fuel consumption in Europe to reach this goal by 2050. Even if gas emits less CO2 per kWh in the power sector compared to oil or coal, it is not a green source of supply such as the renewables and the gas sector can

potentially be targeted by institutions in order to reduce its share in the European energy mix. Such a decision would result in a different model for the future of the European gas market, with less U.S. LNG and probably less Russian gas and a different distribution of the market shares. Also, concerning policies and trade, the growing tensions with the U.S. concerning tariffs on European goods imported to the U.S. can result in retaliatory measures from the European Union, and U.S. LNG could be targeted with higher tariffs, resulting in a much lower market share in the European gas market than what the models suggest. From the Russian side, another crisis with Ukraine could arise in the future, leading to a new shortfall of Russian gas passing by Ukraine. The Nord Stream 2 pipeline is a sensitive project, already threatened by sanctions from the U.S. and bypassing Ukraine to deliver gas to Europe, creating more tensions between Ukraine and Russia because less gas will flow by Ukraine, reducing the fees for the State. This could lead to a new supply disruption and also change the quantities of Russian gas flowing to Europe in the future, obliging Europe to import gas from other sources and as a result to reduce the Russian market shares in the European gas market.

Additional factors, such as an improvement in energy efficiency and the deployment of renewables energies could reduce the need for natural gas in the power sector and the global demand in Europe, as less energy will be required to produce the same output. Renewables can compete with gas or gas can come as a supplement to renewable energy when the production from wind turbines or solar panels is too low, this would also change the quantity of gas required depending of this choice. Natural gas will also have to compete with greener gas such as biogas or hydrogen, the enhancement of the technology in that sector can result in a decrease of natural gas demand by citizens or industries.

All the factors detailed previously have an influence over the gas sector and can modify the expected forecasts that this study suggests. From a pure economic point of view, the analysis provides a clear understanding of the gas market and what should be taken into account to assess

the future of the demand side and the supply side, but this section is designed to remind that other factors also have an influence over the future of natural gas and should not be forgotten.

3.2 Conclusion

The findings are mainly going toward one direction, that the competition in the European gas market between Russian and the U.S. is at an early stage. The U.S. has not yet reached its full export capacity to compete sufficiently with Russia but this should be the case in the next decade. Russia is also reinforcing its position in the European gas market with different pipelines and, to a lesser extent, LNG projects. Concerning the research question, about the possibility for the U.S. to challenge Russian gas within the European Union in the long-term, the answer is positive. Firstly, because the U.S. are already challenging Russia in the gas sector, as explained in the price comparison section, the U.S. delinked the price of natural gas compared to gas, increasing the competitiveness of its LNG, and this obliged Russia to modify its price structure for the gas exported to Europe, as a consequence, the price of Russian gas dropped and allowed Europe to pay less for the same volume of natural gas imported. This is already a first step completed by the U.S. in challenging Russia in the European gas market. Secondly, concerning volumes of gas exported to Europe, Russia will remain the first supplier for the EU28 in any scenario, because of its large pipeline capacity connected to Europe, no other countries can achieve a similar level of interconnection with the European Union. However, the U.S. only began to ship LNG to Europe in 2016 and since then, its level of export increased significantly and this trend shows no sign of decline. The U.S. is building a long-lasting position in the European gas market and should achieve to control, at the minimum, 15% of the market share in Europe by 2028 and 24% at the maximum. Even if this share is inferior to the Russian one, this will have implications and result in a positive outcome for the European Union. Depending if the natural gas spot price is high or low, the influence of the U.S. will not be the same in Europe, but it will increase European energy security anyway and initiate a cap price for natural gas that Russia will not dare to exceed or the country will risk to lose market shares. In the case of a high spot price scenario, the U.S. will not compete against

Russia with the same strength than with a low spot price and Russia will account for the bulk of the exports, at 50% by 2028. Such a scenario would be hazardous for the EU as the influence of Russia will be at an all-time high, despite the fact that the U.S. will allow Europe to diversify its sources of supply, supposed to increase energy security. With the current figures and the level of American gas production increasing, the global price of gas is less likely to rise than to fall, because the market is well supplied, the demand in Europe should decline according to the forecasts, giving directions that the natural gas spot price will probably remain low in the coming years. The more likely scenario to take place is the one with a low spot price for natural gas, stimulating competition against the different players in the market. Such an outcome would allow the U.S. to build a robust second position as a natural gas supplier in Europe and to severely challenge Russia in Europe. Energy security in Europe would be much more effective with a U.S. LNG able to counterbalance Russian gas and reduce the market share of the Russian Federation. It will be at the benefit of Europe, able to build a more resilient market to gas disruption and reduce the influence of Russia over the European energy sector but also over European affairs in general. In that scenario, if Russia threatens to stop delivering gas to Europe or if any other issue occurs, the European Union holds a reliable escape route with the U.S. and should be able to manage more efficiently and with a better prevision any threats concerning its natural gas market.

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