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# Replacing Russian gas with that of the United States: A critical analysis from the European Union energy security perspective

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**Abstract**

The security of gas supply is one of the main concerns for the European Union (EU), especially when considering the EU's dependence on Russian gas. The idea of importing liquefied natural gas (LNG) from the United States has recently emerged as an alternative to reduce EU dependency on Russia. However, the idea still needs to be evaluated, especially the extent to which it is beneficial or practicable for EU gas security. Composing as it does an appropriate indicator, namely the risks to the EU gas supply, this current research attempts to evaluate the idea of substitution. The composed touchstone comprises critical elements, including political risks for gas supply and transit, the importance of natural gas imports in the gross domestic product, and fungibility of the import. This indicator has then been applied to six selected member states. The results of our analysis indicate that importing gas from the United States improves supply security in five cases. Nevertheless, the benefits of substitution should be evaluated considering the limitations of available infrastructures and the economic factors. This could suggest that importing the U.S. LNG can be a feasible policy for Poland and the Baltic States, however, not necessarily for Germany, Italy and, especially, France. Therefore, replacing Russian gas with the U.S. LNG entails some prerequisites before being considered a beneficial alternative for EU gas security.

*Keywords:* U.S. LNG, Russia, energy security indicator.
*JEL classification:* F5.

## 1. Introduction

The European Union (EU) is currently a net importer of natural gas, mainly from Russia. In fact, the Soviet–Austria gas deal signed in the 1960s paved the way for Russian gas to arrive in the European market. The deal was extended

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in the aftermath of the Soviet Union's collapse. Russia was known as a reliable energy partner for the EU in the eyes of the European Commission until the early 2000s (European Commission, 2000); however, the Russia–Ukraine gas disputes in 2006 and 2009 changed this assumption. While even today the EU has remained dependent on Russian gas for up to 43.6% of its import in 2020 (Eurostat, 2021), some EU member states have been actively following policies to lessen their dependence on Russian gas. The current conflict between Russia and Ukraine has only increased this intention. These policies mainly include diversification of supply sources or routes, and decreasing Russian gas imports in order to bolster resilience against potential interruptions to the Russian gas flow.

Nevertheless, the EU could not find many reliable alternative gas suppliers to diversify its supply sources. Concluding gas deals with the significant Middle Eastern gas owners did not go beyond importing a limited number of liquefied natural gas (LNG) cargos from Qatar, mainly due to security, political or economic difficulties. Moreover, the realization of the Eastern Mediterranean gas export to the EU still depends on overcoming critical commercial and legal challenges facing the region (Karbuz, 2021). Additionally, while Caspian basin gas resources looked very reliable for the EU in the early 1990s, they remained limited to one supplier, i.e. Azerbaijan, and the main gas transportation project, the Trans-Caspian Gas Pipeline (TCGP), does not look likely to be accomplished soon in order to transfer giant gas volume to the EU (Gurbanov, 2018). Unlike in the cases of the aforementioned resources, a light at the end of the tunnel emerged for the EU, when the U.S. rapidly enhanced its LNG export capacity by virtue of the shale gas boom (Richman and Ayyılmaz, 2019). However, not all member states eagerly embraced the U.S. LNG, as some of them, such as Germany, even followed their policy to strengthen gas relations with Russia, including by construction of the controversial Nord Stream II pipeline.

Perceiving Russian gas as a threat to the EU has been the dominant rationale behind the idea of replacing Russian gas with other sources, and potentially the U.S. LNG (Bordoff and Houser, 2014). However, it is necessary to distinguish between two different types of threats when different scholars address Russian gas: a "geopolitical leverage" which the Kremlin applies to bully the Union with the aim of influencing neighbors (Collins, 2017; Smith, 2009), and as a threat against member states' "energy security" considering the EU's low resilience against gas interruptions, in general (Richter and Holz, 2015; Ruban, 2013). The first perception stands on political (or moral) principles to contemplate how Russian gas imports can fuel the Kremlin's foreign policy, and should be stopped. Comparatively, the second perspective tries to prove how fragile the security of the Russian gas supply is for the EU, especially when we recall the Russia–Ukraine gas disputes of 2006 and 2009.

The purpose of this research is mainly to focus on the latter threat perception. It seeks to assess the effectiveness of potential replacing Russian gas with the U.S. LNG with the aim of enhancing the EU's security of gas supply, using quantitative methods. In other words, this research does not examine the idea of neutralizing Russia's efforts in using its gas as political leverage. Instead, we probe to determine to what extent substitution of Russian gas with the U.S. LNG will decrease gas supply risks for significant importers of Russian gas within the Union. Therefore, it does not analyze to what extent reducing reliance on

Russian gas imports can be viewed as a politically wise decision, but, rather, how much substitution of Russian gas with the U.S. LNG is beneficial merely from the perspective of the EU's security of gas supply.

The importance of the research is proved from three different perspectives. First, Regulation 2017/1938 of the European Parliament and the Council calls upon the EU member states "to take essential measures to safeguard the security of gas supply." Therefore, the replacement policy should be evaluated if it is in line with the main outline of the Regulation, i.e. security of gas supply enhancement. Moreover, while the environmental aspects of the EU's energy policy get more attention in resource allocation, especially after the EU Green Deal introduction, the geopolitical concerns of supply security have remained on the table (Keypour and Ahmadzada, 2022). Hence, evaluating capital intensive solutions like the LNG substitution is critical in optimizing the EU resources allocation when supply security is targeted. Finally, understanding the effectiveness of the replacement policy is essential for the Union to preserve an independent energy policy while the U.S. tries to influence the EU–Russia gas relations. One can perceive such efforts of the United States in its sanctions imposed against Nord Stream II.

EU–Russia gas relations have been studied from an energy security perspective before. Significant attention has been paid to discussing the impacts of Russian gas import on the EU, from the geopolitical perspective, e.g. whether the Kremlin can use it as a weapon against the EU. Also, some other publications talk about the benefits of diversification of supply by relying on alternative resources, like Eastern Mediterranean, Iran, Central Asia, but neglecting the extent to which these resources are accessible for the EU, or without offering a yardstick to prove if such substitution can actually boost the EU's energy security. This study focuses on the U.S. LNG, perceiving it as the currently available alternative for decreasing the EU dependence on Russian gas. Furthermore, while Regulation 2017/1938 has introduced the "$N$ – 1 index" for measuring the risks threatening EU member states' gas supply security, the current research aims to develop the index to include additional factors for assessing the security of supply. It provides a quantitative ruler for evaluating the efficiency of the U.S. LNG replacement impacts on the EU energy security.

The central claim of this paper is that importing the U.S. LNG is not conducive to enhancing all the member states' energy security, and therefore, it should not be treated equally in all parts of the EU. Moreover, it establishes that even in cases where the index proves the benefits of the U.S. LNG, it may require the member state to cede some advantages connected to the import of Russian gas, such as the transit revenue. Therefore, the research question is: "To what extent does replacing Russian gas with the U.S. LNG enhance the security of gas supply to the EU?"

This article is divided into the four sections below. The following section provides a methodological background to develop the indicator for measuring gas supply security and how it differs from previously designed indices. The results section demonstrates how the value of the composed indicator can change in each selected EU member state through the replacement of Russian gas with the U.S. LNG using the latest available statistics. It stands to reason that since the COVID-19 outbreak distorted the overall energy market, this research has used the last available data before the pandemic, i.e. from 2019. Section 4, as the analytical framework, discusses the results to evaluate the possibilities and limitations of implementing the replacement policy. Finally, the paper ends with our conclusions, recommendations, and proposals for future research.

## 2. Methodology

### *2.1. Energy security: Definition and indices*

Although energy security is an issue of critical importance for many different stakeholders, no consensus exists about its definition among scholars (Ang et al., 2015). However, many of these rendered definitions greatly resemble one another (Sovacool, 2011). This enables us to select one of them according to our goal, while many others are still compatible with it. For the aim of this research, energy security is defined as providing affordable, accessible, available, and acceptable energy for customers (Kruyt et al., 2009). In this research, we mainly consider the "accessibility" component corresponding to the geopolitical aspects of energy security. The other elements of this "4A" definition are classified into availability (geological existence of energy resources), affordability (the economic considerations) and acceptability (the environmental and societal issues). Considering our aim of focusing on accessibility, the components of the composed index will be explained as follows.

#### *2.1.1. Political risks of supply ($PR_s$)*

Since one of the most critical sources of geopolitical risk of supply comes from dependency and concentration in the energy consumption portfolio, we assume these risks are measurable using the Herfindahl–Hirschman Index (HHI) (Pavlovića et al., 2018):

$$\text{HHI} = \sum_{i=1}^{n} (100x_i), \tag{1}$$

where $x_i$ is the market share of the $i^{th}$ gas supplier for a specific importer.

HHI is used to measure competition (or diversity) instead of dependence as an indicator of risks relating to a particular source or supplier. The higher the HHI, the higher the concentration, which means the system being examined is less diverse (Rubel and Chalvatzis, 2015). Therefore, if the number of suppliers is infinite ($n \to \infty$), HHI "approaches" zero. This represents a market with perfect competition, while HHI = 10,000 indicates a total monopoly ($n$ = 1), due to the existence of a single supplier.

$$PR_s = \sum_{i=1}^{n} (pr_{s_i} \cdot x_i^2), \tag{2}$$

where $pr_{s_i}$ shows the normalized $PR_{s_i}$, i.e. by dividing $PR_{S_i}$ by the highest $PR_S$ value (represented by the worst state in the reference source). While $PR_s$ includes political risks for different suppliers, $\sum x_i^2$ can cover diversification concerns. Therefore, through equation (2), $PR_s$ meets the requirements for having both geopolitical risks and diversification (or dependence) indicators.

Not many studies have attempted to quantify the geopolitical risks required to estimate $PR_s$ according to equation (2). Some resources choose simple indicators, like the Human Development Indicator (HDI) as the reference, and others rely on more complex indices. Nevertheless, indicators like HDI look too straightforward for identifying geopolitical risks of energy supply (Kruyt et al., 2011). Muñoz et al. (2015) have quantified the geopolitical dimension of energy risk for 122 sovereign states. The combination of geopolitical and social dimensions in a single risk vector is vital for the current research aims, and their research meets this criterion reasonably. Although it was made in 2014, however, even at that point tensions were high between Russia and Ukraine in the aftermath of the Crimea annexation. Therefore, one can consider it still viable, as tensions have again escalated. Also, $x_i$ is extracted from ENTSOG (European Network of Transmission System Operators for Gas) and, if necessary, validated by provided data from BP (2020) and Gazprom (2020).

### *2.1.2. Political risks of transit ($PR_T$)*

While sporadic piracy cases exist involving LNG tankers, there are examples of how transit counties may (pretend to) use energy flow as a political lever against the importers, like how Belarus threatened the EU with Russian gas in response to Brussels' efforts to impose sanctions against Minsk (Aarup, 2021). Hence, it is logical to include the influence of political transit risks in the composing index. Le-Coq and Paltseva (2012) tried covering this by proposing an indicator for gas transit risk, focusing on the Russian case as the supplier. In their work, transit states are considered as having bargaining power commensurate to the volume of gas passing through their territory. While this is applicable for the transiting states to make concessions from the main supplier, it does not cover geopolitical risks of supply or transit pointing to the final importer. Other research has attempted to focus on one specific European importer's security of supply, such as Croatia (Pavlovića et al., 2018) and Italy (Bompard et al., 2017), or to evaluate the importance of the EU's infrastructure development for improving supply security through an economic rather than a political concept and approach (Abrell and Leo Chavaz, 2019).

Contrary to the research mentioned above, we prefer to concentrate on political risks rather than on technical ones. Basically, the political risk raises a certain level of "uncertainty" since interruptions caused by them are more challenging to predict than technically-induced blackouts or power cuts. Additionally, whenever they arise, it is not easy to estimate when they will disappear. Muñoz et al. (2015) claimed that their rendered data could also estimate the geopolitical energy risk for entire energy corridors by aggregating the geopolitical energy risk of the exporting and transit countries.[1] Assuming the importing gas passes through some transit states ($m$), total political transit risk equals the aggregated transit risks caused by each country. When this is multiplied by the risk for each route, we compute and then add to the risks attributed to other transit

[1] One may debate that even bilateral relations between the supplier and all transit states need to be accounted for (especially due to the Ukraine–Russia crises of 2006 and 2009). However, such data is not available to the best of our knowledge.

states, finally resulting in total political risks of transit, $PR_T$. Therefore, they are defined as follows:

$$PR_T = \sum_{j=1}^{m} x_j \cdot \sum_{i=1}^{n} pr_{s_i}. \tag{3}$$

While $x_j$ is the proportion of imported gas passing via the $j^{th}$ route (quoted by ENTSOG), $\sum_{i=1}^{n} pr_{s_i}$ adds up the political risk of transit states in the $j^{th}$ route (quoted by Muñoz et al., 2015).

The total political risk (TPR) of a hypothetical supplier across a certain route can be calculated by adding $PR_T$ to $PR_s$, as below:

$$TPR = PR_T + PR_S. \tag{4}$$

It is worth mentioning that since the range of both sub-indicators, $PR_T$ and $PR_S$, is from 0 – 1, and both terms are dimensionless, the two terms are consistent to be added.

### *2.1.3. Natural gas import dependency*

The importance of, and dependence on imported Russian gas is not uniform for all EU member states. For example, while the Eastern and Baltic States are heavily dependent on Russian gas, Western EU states have diversified their gas imports' portfolio. As a result, member states' economic vulnerability varies when it comes to disruptions to Russian gas. To calculate this concept, one can divide the net gas import from Russia to the Gross Domestic Product (GDP) based on purchasing power parity (PPP), as below:

$$\textit{Natural Gas Import Dependency (NGID)} = \frac{\textit{Imported Russian Gas Volume}}{\textit{GDP}}. \tag{5}$$

In a sense, this may represent the financial possibility to switch from this source to others, as well. The imported Russian gas data has been extracted from ENTSOG, validated by two other sources of Gazprom and BP. GDP is extracted from IEA (2020), which quotes it based on the OECD and the World Bank.

### *2.1.4. Fungibility (F)*

The European Commission recommends that member states enhance their energy resilience, including strategic storage capacity, installing more LNG importing facilities, and constructing new interconnectors to boost the EU natural gas network in the reverse direction (European Commission, 2014). This rationale has been reflected in enshrining the fungibility element in the rendered index. It indicates the functionality of the state against any gas supply disruption, relying on the state's infrastructure and alternatives available for meeting its gas demand via alternative methods. This also increases the bargaining power of a final customer in negotiations with a certain supplier in terms of the contract, particularly regarding pricing. For example, when Lithuania launched its first LNG terminal in Klaipeda, it received a 20% discount from Gazprom, even though it had raised gas prices for the Baltic States in 2011 (Grigas, 2014).

In line with the Commission's recommendations, and the $N-1$ formula, the higher the "backup capacity." the higher the resilience is. The fungibility potential comes from the operational LNG importing facilities, Underground Gas Storage (UGS) capacity, and available interconnectors (IC). We assume that the resilience of an importing gas state has a positive relationship with the availability of alternative supply options. The total capacity of all these facilities provided should be assessed compared to the demand volume to evaluate the usefulness and performance of these options in an emergency. Therefore, fungibility is determined as follows:[2]

$$F = \frac{Available\ Capacity\ of\ (LNG + UGS + IC)}{Annual\ Natural\ Gas\ Demand}. \tag{6}$$

Interconnector capacity and UGS capacities data were extracted from ENTSOG (2020). Corresponding data required for LNG was obtained from the International Gas Union (IGU) and was validated with data provided from ENTSOG (2020).

Now, considering all the elements as mentioned above, the composite aggregated Gas Supply Security Indicator (GSSI) is defined according to equation (7):

$$GSSI = \frac{F}{TPR \cdot NGID} \cdot 100. \tag{7}$$

The GSSI index can render an applicable ruler for the aim of our research. While the fungibility indicates the bargaining power against a supplier, it can also show the resilience level against any interruption of gas supply using the backup capacities. The two elements of NGID and TPR in the denominator can represent the level of vulnerability against both a supplier and its corresponding transit routes and on natural gas in general, based on the diversity of the supply portfolio. The relative importance of each component of GSSI is not apparent, and, therefore, equal weightings have been considered.

### *2.2. Case selection*

Russian gas is not distributed across the EU in the same vein and through one route. While the Yamal–Europe pipeline passes through Belarus and Poland to reach Germany, Nord Stream lies on the Baltic Sea to arrive in Northern Germany, and the traditional route of Russian gas passes through Ukraine to be distributed in Central and Southern Europe (Gazprom, 2020). Additionally, Netherlands and Norway supply a part of EU gas demand (BP, 2020). Due to the expanded connections in the European gas network, different suppliers' gas is mixed somehow so that is difficult to distinguish which source the flowing gas in the pipelines comes from at any given time. However, relying on the provided data by ENTSOG, we can distinguish the dependence of the bigger member

[2] It includes the storage capacity measured in billion cubic meters (bcm) and operational (regasification terminals and interconnections) capacity expressed in bcm/annum. One can assume the latter one is multiplied by one year.

**Table 1**
The share of Russian gas directed to each EU member state, 2019 (%).

| State | Share of the state from total Russian gas export |
|---|---|
| Germany | 32.99 |
| Italy | 24.96 |
| France | 8.02 |
| Poland | 6.03 |
| Austria | 4.38 |
| Czech Republic | 4.21 |
| Netherlands | 3.14 |
| Hungary | 3.01 |
| Slovakia | 2.55 |
| Greece | 2.04 |
| Finland | 1.78 |
| Bulgaria | 1.65 |
| Croatia | 1.46 |
| Latvia | 0.91 |
| Romania | 0.82 |
| Belgium | 0.81 |
| Lithuania | 0.68 |
| Estonia | 0.68 |
| Slovenia | 0.27 |
| Ireland | 0.26 |
| Spain | 0.04 |
| Portugal | 0.00 |
| Sweden | 0.00 |
| Luxembourg | 0.00 |
| Malta | 0.00 |
| Cyprus | 0.00 |
| Denmark | 0.00 |

*Sources:* Statistica.com; Gazprom (2020); BP (2020); ENTSOG (2020).

states on Russian gas and the final destination where it goes to. Table 1 indicates how much of the exported Russian gas ended up in each member state in 2019. Considering this table, the six states—Germany, Italy, France, Poland, Austria and the Czech Republic—consume 80% of the total Russian gas exported to the EU. These six states will be selected as the case studies for this research.

## 3. Results and implications

Applying the extracted data from ENTSOG (2020), BP (2020) and Gazprom (2020), the flow of Russian gas through different routes to the six selected member states is depicted in Fig. 1. The complete composition of member states' gas source portfolio can be derived as demonstrated in the Appendix.

Using the provided data on the geopolitical risk of energy for each provider and transit state according to Muñoz et al. (2015) and considering the import gas portfolio in each selected state depicted in Appendix and Fig. 1, one can calculate the total political risk of supply, TPR according to equations (2), (3) and (4). The NGID can be calculated using equation (5) and having the capacity of interconnectors, UGS facilities and LNG terminals in each state; fungibility ($F$) can also be derived from equation (6). Finally, GSSI is obtained from equation (7). The corresponding data for the research cases is demonstrated in Table 2.

One can repeat the calculation of GSSI once again, applying it to the situation where the vacant capacity of LNG terminals in these member states is used for

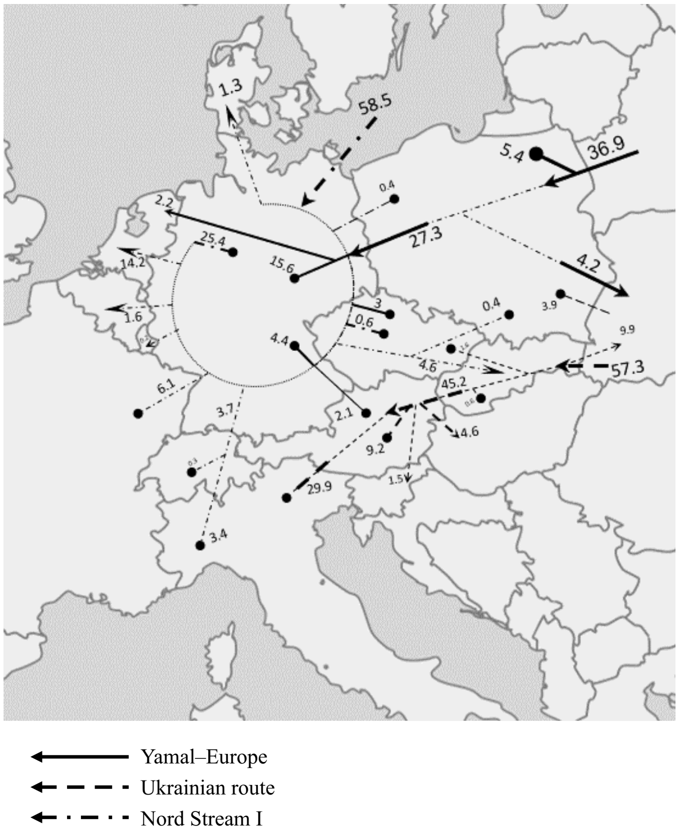


**Fig. 1.** The flow of Russian gas through different routes to the case states in 2019.

*Note:* Filled circles show final destination.
*Sources:* ENTSOG (2020); BP (2020); Gazprom (2020).

**Table 2**
Gas Supply Security Indicator calculation details for the case studies.

| State | TPR | NGID | F | GSSI |
|---|---|---|---|---|
| Germany | 0.36 | 85.21 | 2.81 | 9.16 |
| Italy | 0.48 | 106.71 | 2.05 | 4.00 |
| France | 0.07 | 44.72 | 2.49 | 80.93 |
| Poland | 0.51 | 27.79 | 3.51 | 24.55 |
| Austria | 1.08 | 66.08 | 7.29 | 10.26 |
| Czech Republic | 0.19 | 76.73 | 8.99 | 60.58 |

*Source:* Author's calculations using data from IEA, BP, ENTSOG and IGU.

importing LNG from the United States. It means removing the same volume of imported Russian gas from their import portfolio. Therefore, the new derived GSSI index can indicate how replacing Russian gas with U.S. LNG impacts the security of gas supply, considering the available facilities in reality. This could mean that Italy, Poland and France replace the import of 7.4, 1.5 and 6.1 bcm/annum of LNG from the United States, respectively, with Russian gas.

In the case of the landlocked states, i.e. the Czech Republic and Austria, one may assume that LNG can be imported by hiring the vacant capacity of neighbors' terminals and transferring the re-gasified LNG through the interconnectors.

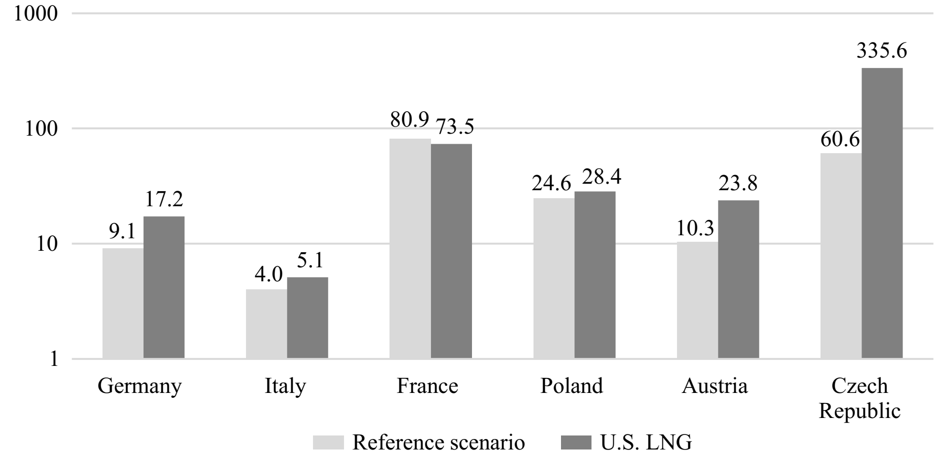


**Fig. 2.** The GSSI of selected EU member states in reference scenario and US LNG substitution with Russian gas.

*Source:* Author's calculations.

Such an assumption is vividly acceptable given that the unutilized capacity of neighbors' LNG terminals suffices importing 9.2 and 1.6 bcm/annum gas for meeting the demand of Austria and the Czech Republic. For Germany, which does not have any operational LNG terminal, a total of 20 bcm of Russian gas (15.6 + 4.4) was imported via transit routes (excluding the Nord Stream). One can assess the impact of 20 bcm replacement by the U.S. LNG, given that Germany's neighbors' total unoccupied LNG capacity is sufficient for achieving this goal, according to the World LNG Report statistics. Additionally, ENTSOG data approves that transmission of the re-gasified LNG via interconnectors to Germany is possible from a technical perspective.

The new index, $GSSI_{U.S.\ LNG}$, is comparable with the GSSI in the reference scenario, as depicted in Fig. 2. The results show that such substitution can slightly enhance the GSSI of Italy and Poland, and more importantly, Germany and Austria, and especially of Czech Republic. However, France experiences a fall in its GSSI as a consequence of this substitution.

## 4. Discussion

Considering the results of GSSI calculations, one can evaluate the effectiveness of LNG replacement policy for all the six member states, as follows.

### *4.1. Germany*

The first noticeable fact about Germany is that Russian gas export to this country no longer transits via Ukraine, but instead through Belarus–Poland (via the Yamal pipeline), or is transported directly via Nord Stream (Pirani and Yafimava, 2016). Thus, the geopolitical transit risk is attributed solely to the Yamal pipeline via Belarus, as the other route (Nord Stream) connects Russia directly to Germany. Although it is the EU's biggest natural gas consumer and importer, its importing portfolio is relatively diversified as indicated in the Appendix: Norway (24.66%), Netherlands (25.57%), Russia (23.37+18.58%), and other EU nations (2.39%). Moreover, Germany benefits from the high connecting pipelines' capacity, which can provide reliable backup and the available UGS facilities in the absence of any LNG terminal.

The results show that the U.S. LNG replacement can improve Germany's security of gas supply as the $GSSI_{DE, U.S. LNG}$ reaches 17.2 from the initial level of 9.1 in the reference scenario. The positive impact of the U.S. LNG on German GSSI is compatible with the current field facts, as such alternation removes the political risks attributed to the Yamal pipeline for Germany. This connotes the future ambiguities around the Yamal route operation under the influence of the uncertainties of the long-term gas transit contract between EuRoPol GAZ and Gazprom, expired on May 18, 2020. Poland's PGNiG declared its reluctance to extend the long-term gas supply agreement with Gazprom on Yamal, and Gazprom had not expressed its interest in using Yamal capacity either (Pirani et al., 2020; Jakóbik, 2021). Therefore, the U.S. LNG can alleviate Germany's energy transit concerns.

Nevertheless, the results should not be interpreted to the absolute advantage of the U.S. LNG for Germany. First, Germany does not have an operating LNG terminal yet, which means U.S. LNG should be imported through other neighbors, as mentioned before. While ENTSOG data proves that their LNG terminal and reverse flow capacities suffice to replace Russian gas imported to Germany via Yamal, a conflict of interests may arise if these neighbors want to use their unbooked capacity to import LNG for other purposes, such as meeting their own needs. One solution is accelerating the planned LNG units in northern Germany, i.e. Wilhelmshaven and Brunsbüttel. However, such an idea is also problematic. According to German Uniper's CEO, Klaus-Dieter Maubach, "it is becoming difficult for LNG to be competitive in the German market due to the good supply situation through pipelines−and with Nord Stream II, another one is coming" (Wettengel, 2021).

Our complementary calculations affirm Maubach's statements; Germany's GSSI can reach 13.51 if substitution of NS II instead of Yamal is considered, which is a promotion contrary to the current value of 9.1. Although this is still lower than $GSSI_{DE, U.S. LNG}$, NS II can provide cheaper gas to Germany given that the U.S. LNG cargos delivered to Germany's neighbors are more expensive than the Russian gas to the German market (IEA, 2021). Additionally, NS II is expected to lower the price of Russian gas in Germany and Western Europe further (Goldthau, 2016; Günther and Nissen, 2019). This makes NS II even more advantageous for Berlin. In addition to economic considerations, NS II is a crucial project for enhancing Germany's role in the European gas market, as it increases the transit flow through Germany by 17 bcm, enhancing the liquidity of Central European gas hubs (Goldthau, 2016). But in February 2022, the geopolitical situation in Europe has radically changed because of Russia's military operation in Ukraine, and the prospects of NS II remain highly uncertain.

### *4.2. Italy*

Among the six selected member states, Italy has the lowest GSSI. This is because it imports more than 42% of its gas needs from Russia, mainly through

Ukraine–Slovakia–Austria (north-eastern route), while a small portion also comes via Germany–Switzerland (north-western route), as depicted in Fig. 1. While the former still plays a prominent role, the latter is expected to be utilized more if NS II is launched. Until then, Italy is vulnerable to supply interruptions (Pirani, 2018). The $GSSI_{IT,\ U.S.\ LNG}$ shows little promotion compared with the reference scenario since the vacant capacity of LNG terminals is just 18% (IGU, 2019). This limits the manoeuvrability of Italy for replacing Russian gas with U.S. LNG. Unlike with Germany, the possibility of importing LNG via neighbors is highly curtailed for Italy due to the lack of sufficient reverse flow interconnectors with France. This can explain why $GSSI_{IT,\ U.S.\ LNG}$ is not much higher than the reference scenario.

One may suggest expanding the capacity of the interconnector or considering new LNG terminals in Italy for U.S. LNG, especially using EU's financial aid. However, the EU's main focus in energy policymaking has been gradually switched to the climate targets rather than the security of supply (Keypour and Ahmadzada, 2022). The Commission is revising corresponding legal outlines of energy infrastructures development like the Trans-European Networks for Energy (TEN-E) Regulation and the Projects of Common Interests (PCI) framework in the same vein. Under the new TEN-E and PCI structure, it will not be easy to apply for the EU's financial aid to develop gas infrastructures, especially for enhancing gas supply security, like new LNG terminals in Italy. Therefore, within the available infrastructures, the positive impact of the U.S. LNG replacement in Italy's gas market remains tiny.

### *4.3. The Czech Republic and Austria*

As indicated in Fig. 1, the Czech Republic meets almost one-third of its demand from the OPAL pipeline as an extension of the Nord Stream. It also receives 1.6 bcm through Slovakia, which comes from Ukraine per se. Austrian dependence on the Ukrainian route is higher than that of the Czech Republic, and its import portfolio is less diversified, increasing risks (see Appendix). At first glance, LNG importation to the landlocked states of the Czech Republic and Austria seems non-existing *ab initio* due to their lack of access to the sea. Nevertheless, their relatively small market volume makes it possible to rely on the vacant capacity of the neighbors' LNG terminals, like Italy and Poland. The impact of this substitution on $GSSI_{CZ}$ is magnificent; it rises from 60.58 to 335.6. This sharp growth is justifiable due to two facts: the U.S. LNG diversifies the Czech gas portfolio, decreasing $PR_s$ according to equation (2); it also reduces $PR_T$ as the Czech Republic reaches non-dependency on Russian gas coming from the Ukrainian route. The same goes for Austrian GSSI.

While the positive impact of the U.S. LNG on the Czech and Austrian gas supply security is undeniable, other factors may moderate policymakers' decision to lean towards the U.S. LNG. First, the price of imported LNG may not look competitive; exacerbated even more so in Germany's case, whose situation we have already described, since the transit fee will be added to the importing LNG. Furthermore, given the Austrian and Czech Republic's involvement in Central and Western European (Russian) gas-distributing, the likelihood of these states substituting Russian gas with U.S. LNG to any significant degree is slim. Jirušek (2020) has shown how the Czech Republic reoriented its stance favoring NS II and closer to the market-oriented attitude in recent years, making any redirection of gas supply patterns unnecessary for Prague. This is discernible, especially after the 2017 Gazprom long-term deal on gas transit through the Czech Republic until 2050.

In addition to NS II, another newcomer rival for the U.S. LNG, the Turkstream pipeline, should be accounted for. Gazprom started using this line to deliver gas to Turkey, Bulgaria, Greece, and North Macedonia in early 2020. This was followed by feeding Serbia, Bosnia and Herzegovina, and Romania. While the pipeline has not yet extended to central Europe, where Austria and the Czech Republic are, this can happen in the future. In that case, Ukraine's role in delivering gas to Central Europe would be diminished, as it has already happened in Southern Europe. According to Ukrainian authorities, the Trans Balkan Pipeline used to transfer Russian gas to Southern Europe via Ukraine was operating at less than 5% capacity in late 2020 (CRS, 2021). The extension of Turkstream to Central Europe means that Austria and the Czech Republic can reduce the PRT needless of importing LNG from the United States via neighbors. Thus, U.S. LNG can positively impact the Czech Republic and Austrian gas supply security, yet it entails overcoming powerful rivals like Turkstream and NS II.

### *4.4. Poland*

Fig. 2 indicates that Poland can experience a slight improvement in its GSSI using the U.S. LNG. Russia was the main gas supplier in Poland, with more than 53% of the total consumption in 2019 (see Fig. 1). Although Poland gets Russian gas via Belarus and Ukraine, Warsaw can receive gas from Germany via the Nord Stream extension, using the Mallnow gas station reverse flow at the German/Polish border (ENTSOG, 2020). The only Polish LNG Terminal in Świnoujście can also provide up to 5 bcm of natural gas per year. However, as the role of Russian gas has been critical to the Polish gas supply, the $GSSI_{PL}$ is still low. Świnoujście did not work at full capacity, reaching 70% in 2019 (IGU, 2019). Thus, if Poland uses the terminal for altering Russian gas, an additional 1.5 bcm of Russian gas can be substituted by the U.S. LNG, resulting in an improvement of GSSI to 28.4. One can also suggest utilizing the vacant capacity of the Lithuanian terminal in Klaipeda, the Independence, which was used no more than 47% in 2019, to unload other LNG cargoes (IGU, 2019). This will further improve $GSSI_{PL}$ to 33.30 and is conducive to the Independence facilities' economic performance.

Unlike other cases cited above, such as Germany, Poland has solid complementary political motivations to back the idea of Russian gas alternation in addition to the GSSI improvement. In fact, Warsaw has perceived the EU energy cooperation with Russia as a security threat due to its own long-standing adversarial interaction with Moscow (Siddi, 2020). In the aftermath of the 2006, 2009 gas disputes, Poland has tried to portray Russian gas as a "weapon" in the hands of the Kremlin against the EU, ahead of some other Central and Eastern European Countries (CEECs). Therefore, diversification of gas supply sources is mainly justified by political intentions in the eyes of Warsaw (Bocse, 2020; Brown, 2018). Similarly, one can explain the U.S. support for the EU's energy infrastructure projects, considering the political aspects of EU–Russia gas relations, rather than pure economic interests. Given such a convergence in political approaches of the United States and Poland on Russian gas, one can expect to see Poland taking steps to reduce or moderate its reliance on Russian gas by relying on the U.S. LNG. As our research indicated, such a decision can be backed by the GSSI promotion as well.

### *4.5. France*

Unlike the states mentioned above, France would experience a decline in its GSSI if it altered Russian imported gas with the U.S. LNG. This is justifiable considering the country's gas market structure. Currently, France benefits from diversified gas providers consisting of twelve states, and Russian pipeline gas has no significant role (no more than 12%, see Appendix). Moreover, Russian gas is delivered to France without reliance on the Ukraine transit route, according to the gas deal between Gazprom and French GDF SUEZ in 2006, when parties agreed to deliver gas via the Nord Stream until 2030 (Gazprom, 2013), as depicted in Fig. 1. Therefore, replacement of U.S. LNG in France will not significantly improve the $PR_T$, but instead, it disturbs the diversification of the French gas portfolio resulting in higher $PR_s$ according to equation (2). Therefore, such a policy lessens the $GSSI_{FR}$, and it does not look to be a rational choice for Paris.

## 5. Conclusion

This research analyzed the impact of the United States' LNG advent in lowering risks to gas supplies in the European gas market. It is critical to assess this impact because United States LNG has been recognized as a rival for Russian gas, favoring EU gas supply security and diversifying the gas portfolio for European Union member states. Although the EU–Russia relationship has been studied, looking through the lens of gas supply security before, this research approaches the topic relying on a quantitative method, considering geopolitical risks of transit and supply for different case studies. Thus, six EU member states who receive 80% of total Russian gas export to the EU have been selected to study the impacts of the U.S. LNG substitution on their security of gas supply. In order to evaluate it, an index for gas supply security index, called the GSSI, was composed.

Applying the GSSI indicator, this research shows that in the most straightforward case, the United States' LNG is beneficial for Poland as it improves $GSSI_{PL}$ from 24.56 to 28.42. The same goes for Italy, Germany, the Czech Republic and Austria. Among these four member states, Italy is the only one that can count on its own LNG terminals, whereas others have to open their market to U.S. gas using the available vacant capacity of their neighbors. Despite the positive impact of the U.S. LNG on the GSSI of Germany, the Czech Republic and Austria, it stands to reason to assume that the political and economic considerations may prevent decision makers advancing with the U.S. LNG, in reality. Notably, if Nord Stream II pipeline becomes operational (and under present conditions this is very doubtful), Germany can achieve cheaper Russian gas, making it more attractive than the United States' LNG. The implications of the possible extension of the Turkstream pipeline to

Central Europe may appear as another rival for the U.S. LNG in the cases of the Czech Republic and Austria.

The outcomes of our analyses do not support the claim that the United States LNG is realized as the best operational option for the (selected member states of) EU to lower risks to supply. On the one hand, even though in most of the studied cases, the U.S. LNG can enhance the security of gas supply index, i.e. GSSI, implementation of the idea may be restricted due to operational limitations, like available infrastructures or the capacity of the gas facilities. For instance, while we assumed that Germany, the Czech Republic, and Austria could hire the unoccupied capacity of their neighbors' LNG facilities, it may raise a conflict of interests if their neighbors tend to use their vacant capacities for their own demand. One may propose that future developments may set the stage for higher capacities needed for importing additional LNG. However, the EU's gas infrastructure development plans are under review to comply with climate targets. Under such circumstances, using EU financial aid for gas projects will be problematic, especially if it is a matter of supply security rather than decarbonization. The implication of such a climate approach could curtail the capacity expansion needed for importing additional LNG, including from the United States. Nevertheless, it is safe to say that the U.S. LNG seems attractive to Poland compared to other countries in this study. Poland's political motivations back reducing dependence on Russian gas, including with the help of the U.S. LNG.

Although this research effort was designed to compose a holistic index for measuring the security of gas supply, it is not easy to include and evaluate other essential factors in the same index. In a broader sense, while economic and technical considerations have been accounted for in our analysis and interpretation of the GSSI results, environmental issues (the "acceptability" element of the "4A" energy security definition) have remained untouched. One can consider this as a general defect of all rendered indices since none of them is capable of measuring all energy security elements at once. This could mean that simultaneous quantifying of environmental and supply security considerations within one aggregated index is problematic. Thus, the GSSI results should be interpreted considering that the United States' LNG comes mainly from not-so-environmentally-friendly shale gas sources, and therefore, importing the U.S. LNG may be perceived as a breach of EU's climate policies.

Last but not least, our study has limited the transit risk only to political risks of transit states. Even though this is the main component of the transit risk used in a few previous studies, it can be extended to the direct impact of political disputes between transit states and suppliers as well. The required data can be gathered and quantified using a questionnaire-based data collection method in future studies. Moreover, fungibility was limited merely to other forms of gas alternation, neglecting the fact that in some cases, other fuels can be used in emergencies as well, such as coal to fuel power plants. This should be examined closely on a case by case basis, as the generalization is not possible. Although implementing these two points further complicates the study, the result would be more precise and reliable. This aspect proves the diverse level of supply security for member states demand various solutions if higher security levels should be targeted. Finally, the considerable natural gas price gap between the U.S. and Asian markets has historically enticed the American LNG exporters to send their cargoes to the Far East rather than other markets. Therefore, the issue of the U.S. LNG availability should be considered in analyzing the possibility of Russian gas replacement in the European gas market.

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# Appendix

**Table A1**
Natural gas import portfolio for the selected cases, 2019 (%).

| From | To | IT | PL | DE | FR | AT | CZ |
|---|---|---|---|---|---|---|---|
| LNG | Trinidad and Tobago | 2.00 | – | – | 0.58 | – | – |
| | Algeria | 3.87 | – | – | 5.00 | – | – |
| | Angola | – | – | – | 0.77 | – | – |
| | Russia | 0.13 | – | – | 13.27 | – | – |
| | Norway | 0.13 | 0.77 | – | 2.88 | – | – |
| | Nigeria | 0.40 | – | – | 8.46 | – | – |
| | Qatar | 8.54 | 12.69 | – | 3.65 | – | – |
| | U.S.A | 2.14 | 5.22 | – | 5.96 | – | – |
| | Egypt | 0.53 | – | – | 0.77 | – | – |
| Netherlands | | 1.60 | – | 25.57 | 16.92 | – | – |
| Norway PNG | | 3.60 | – | 24.66 | 29.04 | – | 29.73 |
| Russia | UA route | 39.92 | 21.43 | – | – | 81.42 | 21.62 |
| | NS route | – | 2.20 | 23.37 | 11.73 | – | 8.11 |
| | Yamal route | – | 29.67 | 18.58 | – | – | – |
| Other EU member states | | 5.07 | 2.20 | 2.39 | – | 18.58 | 40.54 |
| Algeria PNG | | 13.75 | – | – | – | – | – |
| Libya PNG | | 7.61 | – | – | – | – | – |
| Domestic production | | 6.14 | 25.82 | 5.43 | 0.19 | – | – |
| Total | | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

*Source:* Author's calculations using data from ENTSOG, BP and Gazprom.