Europe's Dependence on Russian Natural Gas and the Disruption of Gas Flows after the Ukraine Invasion: Implications for Energy Security and LNG Shipping Markets

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Prior to 2022, the European Union relied for decades on a deeply formative relationship of energy dependence on Russian gas, a reality explicitly recognized by the International Energy Agency as a fundamental feature of the European energy architecture. This long-standing dependence has become a structural element of Europe's energy system, affecting both the strategic choices of member states and the resilience of the European market in the face of geopolitical turbulence (IEA, 2022). Natural gas has been considered one of the most important forms of energy for many years, the distribution of which has been monopolized by some countries, a fact that may create problems in times of crisis. A recent and important example of such a crisis is the Russia-Ukraine war, if we consider the fact that most European countries were in energy dependence on Russia. Many of these countries turned to liquefied natural gas, which was accessible through alternative sources, resulting in a significant increase in demand (Acik, 2024).

Natural gas is primarily concentrated in regions such as the United States, Australia, Russia, and Qatar (Overland et al., 2022), driving the creation of a global natural gas trade network, which consists of two main transportation methods: pipeline and LNG shipping (Peng et al., 2021). ***This means that the Russia - Ukraine war has profoundly reshaped the LNG shipping network and the global trade flows and volumes.*** Because of the high dependence on Russian natural gas until 2022, the European Union started to change the energy strategy, increasing LNG imports from the United States and other suppliers, in a way that Russia and Ukraine do not have any more a key role in the global shipping network (Sassy, 2025). Russian gas has been a key pillar of European energy security, covering a significant proportion of total consumption, especially in Central and Eastern European countries. Geographical proximity, relatively low pipeline transport costs and the ability to supply large quantities on an ongoing basis further strengthened Russia's role as a dominant supplier, while limiting incentives for substantial diversification of sources and supply routes.

This energy dependency has, however, created significant strategic and structural vulnerabilities for the European Union, as it linked energy sufficiency to geopolitical and political factors beyond its control. The limited development of alternative infrastructure, such as liquefied natural gas terminals and interconnections between member states, combined with the high dependence of certain economies on a single supplier, has increased the risk of systemic disruptions. At the same time, the long-term focus on conventional pipeline flows delayed the transition to a more flexible and diversified energy mix, which became evident when geopolitical conditions changed radically (Liu et al., 2025).

Following Russia's invasion of Ukraine, Russian gas flows to Europe have drastically decreased, suddenly upsetting the continent's existing energy market. Disruptions and gradual reductions in deliveries through key pipelines highlighted the highly politicised nature of energy dependency and made it clear that security of supply could no longer be taken for granted. This development has led to ***severe imbalances between supply and demand,*** causing intense pressures on energy markets, increased uncertainty, and significant fluctuations in natural gas prices at the European level (Di Bella et al., 2024). The sharp contraction of Russian flows has forced European states to look for immediate ***alternative sources of supply,*** accelerating the shift to liquefied natural gas and the reshaping of trade and shipping routes (Grammenos, 2026). At the same time, efforts were intensified to increase stocks, strengthen interconnections and implement energy saving measures to limit the risk of shortages. This development highlighted the structural weaknesses of the European energy system, but at the same time acted as a catalyst for the transition towards a more diversified, flexible and resilient energy supply model (Ma & Huang, 2025).

The experience of the abrupt interruption of Russian gas flows acted as a catalyst for the revision of the European energy strategy, bringing to the fore the concept of energy security as a central policy priority. The European Union has taken a multidimensional approach that has combined ***diversification of sources and supply routes***, strengthened stocks and accelerating the deployment of critical infrastructure. At the same time, coordination mechanisms between member states have been strengthened, with the aim of collectively responding to crises and reducing the asymmetric dependencies that characterized the European energy system in the past (Ah-Voun et al., 2024).

In this broader context, the pursuit of ***strategic autonomy*** has emerged as a key pillar of the Union's energy policy, linking security of supply with long-term sustainability and economic resilience. Strengthening the internal energy market, developing renewable energy sources and reducing dependence on external suppliers were crucial steps towards a more self-sufficient and resilient energy model. Despite the challenges and increased costs of the transition, this shift reflects a strategic choice by the European Union to limit geopolitical vulnerabilities and strengthen its role as an autonomous and reliable actor in the international energy environment (Zolotarova & et al., 2025).

Russia's invasion of Ukraine and the subsequent events involving the Nord Stream infrastructure have dramatically highlighted the vulnerability of gas pipelines and the environmental consequences that can result from the disruption or destruction of critical energy infrastructure. According to a technical analysis of the leak, most of the natural gas was released within the first 48 hours after the pipelines burst, which is attributed to the large pressure difference between the gas inside the pipelines and the hydrostatic environment of the sea. As the pressure decreased rapidly, seawater entered the pipelines but did not act as a substantial obstacle to the release of methane, which, due to its high mobility and low solubility in water, was released almost entirely into the atmosphere. The total amount of methane released is estimated at approximately 478,000 tons, making the Nord Stream incident the largest recorded methane leak worldwide. The environmental impact of the leak is particularly significant, given methane's potent ability to trap heat, with the equivalent of emissions being compared to those resulting from the production of concrete to build dozens of Burj Khalifa-sized skyscrapers. This incident, in addition to the immediate interruption of Russian gas flows to Europe, highlighted the need for stricter pressure management on inactive pipelines, as well as for the design of infrastructure with built-in measures to limit the environmental impact in cases of catastrophic failures, especially in an environment of increasing geopolitical tensions and climate challenges (Poursanidis et al., 2024).

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