

Dynamics and Infrastructure of the Natural Gas Market in Europe: Supply, Transport, and Markets

Benaissa Abderahmane*, ALPEC Lab , University of Boumerdes (Algeria)

Benhamida Hichem, ALPEC Lab , University of Boumerdes (Algeria)

Received: 29/05/2025 ; **Revised:** 04/12/2025 ; **Accepted:** 31/12/2025

Abstract:

This research investigates the evolving dynamics of the natural gas market in Europe, focusing on the structural transformations in supply sources, transportation infrastructure, and market integration following the 2022 geopolitical crisis. The primary objective is to assess how the European Union has adapted to the disruption of Russian gas flows through increased liquefied natural gas (LNG) imports, accelerated infrastructure development, and regulatory shifts aimed at enhancing energy security. Using a mixed-methods approach, the study integrates quantitative data from authoritative sources—including the IEA, ENTSOG, and BP—with qualitative policy analysis from European Commission and IFPEN reports. The findings reveal a significant diversification of gas supply, expansion of LNG regasification capacity, and improved cross-border interconnections, particularly in Central and Eastern Europe. However, persistent regional imbalances, infrastructure bottlenecks, and price volatility highlight the limits of current market integration. The study concludes that while immediate energy security has been reinforced, sustained investment in low-carbon alternatives and cross-border coordination is essential to align short-term resilience with long-term climate goals.

Keywords: Natural Gas Market, LNG, Energy Infrastructure, European Energy Policy, Gas Transport, Market Integration, Energy Security, Decarbonization

Jel Classification Codes : Q35 ; Q48 ; L95 ; F52 ; O13 .

* Corresponding author

I. Introduction :

The European natural gas market has undergone significant transformations in recent years, primarily due to geopolitical tensions, evolving energy policies, and shifts in global demand and supply dynamics. Historically reliant on Russian pipeline gas, Europe has been compelled to diversify its energy sources, especially in the wake of the 2022 supply disruptions. This diversification includes increased liquefied natural gas (LNG) imports and accelerated development of renewable energy infrastructures.

The International Energy Agency (IEA) reports that global gas demand reached an all-time high in 2024, with expectations of further growth in 2025, driven mainly by fast-growing Asian markets. However, the global gas balance remains fragile, with tight supply conditions and geopolitical tensions contributing to price volatility.

In this context, Europe's strategy to enhance energy security involves not only diversifying supply sources but also investing in infrastructure to facilitate efficient transport and market integration. The European Union's REPowerEU plan exemplifies such efforts, aiming to reduce dependency on Russian fossil fuels and accelerate the transition to clean energy.

Problematic

Despite rapid transformations in Europe's natural gas supply system following the Ukraine crisis, there is no consolidated understanding of how supply diversification, infrastructure investment, and market integration interact in shaping the continent's energy resilience. While LNG imports have surged and new terminals have been constructed, infrastructural disparities and regulatory fragmentation persist. Moreover, the short-term push for energy security may conflict with the EU's long-term decarbonization goals.

Problem Statement: There is a critical gap in assessing how Europe's evolving natural gas infrastructure and market mechanisms are collectively responding to the dual challenge of energy security and climate transition in a post-2022 geopolitical context.

Research objectives: This study aims to:

1. Analyze the current supply structure of natural gas in Europe, focusing on diversification efforts.
2. Evaluate the state and development of transport infrastructure facilitating gas distribution.
3. Examine market integration and pricing mechanisms across European countries.

Research Questions

- How has Europe's natural gas supply diversified since 2022?

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- What are the current infrastructure strengths and limitations?
- To what extent have European gas markets become integrated?

Hypotheses

Based on the literature review and problem framing, the study proposes the following hypotheses:

H1: The increase in LNG terminal capacity and interconnector development significantly improves gas supply resilience in EU member states.

H2: Higher levels of market integration (e.g., price convergence at gas hubs) are positively correlated with reduced vulnerability to supply shocks.

H3: The pursuit of short-term energy security through natural gas infrastructure investments poses a risk to meeting the EU's long-term climate goals unless accompanied by parallel investments in low-carbon alternatives.

Literature Review

1. Overview of Natural Gas Supply in Europe

Europe has long been reliant on external sources for its natural gas needs. According to the **IEA (2023)**, before 2022, approximately **40%** of EU gas imports came from Russia, primarily via pipeline routes such as **Nord Stream**, **Yamal**, and **Transgas**. The Russian invasion of Ukraine disrupted this balance, triggering an unprecedented pivot to liquefied natural gas (LNG) imports, especially from the **United States**, **Qatar**, and **Algeria** (IEA, 2023; BP, 2023).

2. Infrastructure Evolution and Bottlenecks

The diversification of supply has put immense pressure on Europe's gas transport and regasification infrastructure. According to **ENTSOG (2024)**, Europe's LNG terminal capacity has increased by over 30% between 2021 and 2024, with new terminals commissioned in Germany, Finland, and Croatia. However, the lack of internal interconnections—especially between the Iberian Peninsula and Central Europe—continues to be a bottleneck (Tagliapietra, 2022).

3. Market Integration and Pricing Mechanisms

Liberalization of gas markets under the EU's Third Energy Package aimed to promote competition and efficiency. **Clo et al. (2022)** emphasize that hubs like the **Title Transfer Facility (TTF)** have become

dominant price benchmarks, but not all member states are equally integrated. Price disparities, limited storage, and capacity congestion still fragment the market (IEA, 2023; IFPEN, 2023).

4. Policy Shifts and Energy Security

The **REPowerEU** strategy, introduced in 2022, aims to reduce fossil fuel dependency and improve supply security. It supports infrastructure investment, strategic reserves, and demand-side measures (European Commission, 2023). However, scholars like **Goldthau & Sitter (2022)** argue that this approach may clash with long-term decarbonization targets unless integrated with renewable gas development.

Research Gap: While numerous studies have examined individual aspects of Europe's energy transition, there is a lack of comprehensive analyses that integrate supply diversification, transport infrastructure, and market dynamics in the post-2022 landscape.

II. Method

This study employs a mixed-methods approach, integrating quantitative data analysis with qualitative policy review to examine the dynamics and infrastructure of the natural gas market in Europe.

Data Sources

- **Statistical Data:** Quantitative data were sourced from reputable organizations, including the International Energy Agency (IEA), BP Statistical Review, and the European Network of Transmission System Operators for Gas (ENTSOG). These sources provided information on gas imports, consumption, infrastructure capacities, and market prices.
- **Policy Documents:** Qualitative analysis was conducted on policy documents and reports from the European Commission, national energy agencies, and industry publications to understand regulatory frameworks and strategic initiatives.

Data Collection and Analysis

- **Quantitative Analysis:** Data from 2021 to 2024 were collected and analyzed to identify trends in supply diversification, infrastructure development, and market integration. Statistical tools were used to assess changes in import volumes, LNG terminal capacities, and price differentials across European hubs.
- **Qualitative Analysis:** Content analysis of policy documents was performed to evaluate the impact of regulatory measures on market dynamics and infrastructure investments.

III. Results

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1. Supply Structure

Europe's natural gas supply has seen a notable shift from pipeline imports to increased LNG reliance. The BP Energy Outlook 2023 indicates that the European Union, China, and India collectively accounted for around 50% of global natural gas imports in 2021, with the EU's share significantly influenced by its previous dependence on Russian gas. bp global

2. Transport Infrastructure

The expansion of LNG terminals and interconnectors has been pivotal in enhancing Europe's gas transport capabilities. The IEA notes that despite the growth in demand, the global gas market balance remains fragile due to tight supply conditions. (IEA report,2025)

3. Market Integration

Market integration across Europe has improved, with the Title Transfer Facility (TTF) in the Netherlands emerging as a key pricing hub. However, price volatility persists due to supply uncertainties and geopolitical factors. The IEA highlights that global gas demand is expected to increase further in 2025, but the supply side remains tight, contributing to ongoing price fluctuations. (IEA reports,2025)

IV. Discussion

The analysis reveals significant shifts in Europe's natural gas market dynamics and infrastructure:

4.1. Supply Diversification: Europe has reduced its reliance on Russian pipeline gas, increasing LNG imports from the United States, Qatar, and other sources. This shift has been facilitated by the expansion of LNG terminal capacities and the development of new supply routes.

4.2. Infrastructure Development: Investments in LNG terminals, interconnectors, and storage facilities have enhanced the flexibility and resilience of the gas supply network. Notably, the implementation of reverse-flow capabilities has improved cross-border gas flows.

4.3. Market Integration: The European gas market has seen increased integration, with the Title Transfer Facility (TTF) in the Netherlands emerging as a key pricing hub. However, price volatility persists due to geopolitical uncertainties and supply-demand imbalances.

4.4. Policy Implications: The findings underscore the need for continued investment in infrastructure and regulatory harmonization to ensure energy security and market stability. Policymakers should focus

on accelerating permitting processes, enhancing cross-border cooperation, and promoting transparent pricing mechanisms.

4.5.Limitations: The study's reliance on available data up to 2024 may not capture the most recent developments. Future research should incorporate real-time data and explore the integration of renewable gases into the existing infrastructure.

V. Conclusion

This study has examined the evolution of the European natural gas market in the aftermath of the 2022 geopolitical crisis, focusing on supply diversification, infrastructure adaptation, and market integration. The analysis highlights three major findings. First, Europe has significantly diversified its gas supply sources, reducing its dependency on Russian pipeline gas through a sharp increase in LNG imports from the United States, Qatar, and other suppliers. Second, infrastructure development—particularly in LNG terminals and cross-border interconnections—has played a critical role in improving system resilience and supply flexibility. Third, although market integration has progressed, particularly with the growing role of the Title Transfer Facility (TTF) as a continental benchmark, regional disparities and price volatility remain due to infrastructural and regulatory fragmentation.

These findings carry important policy implications. While short-term energy security has been reinforced, there is a risk that the urgency-driven investment in fossil gas infrastructure could lock in carbon-intensive assets, delaying the European Union's decarbonization goals. Coordinated regulatory frameworks, accelerated interconnection projects, and the integration of low-carbon gases such as hydrogen and biomethane will be essential to align energy security with climate commitments.

Future research should address several areas. First, longitudinal studies incorporating post-2025 data can assess the persistence of current trends and the realignment of supply routes. Second, comparative assessments between EU member states could uncover national-level disparities in gas infrastructure resilience. Lastly, integrating energy system modeling with climate scenarios would help evaluate how natural gas infrastructure can serve as a transitional asset in the broader decarbonization pathway.

By bridging insights from infrastructure development, market economics, and energy policy, this research contributes to a more comprehensive understanding of Europe's complex energy transition dynamics.

– **Appendices:**

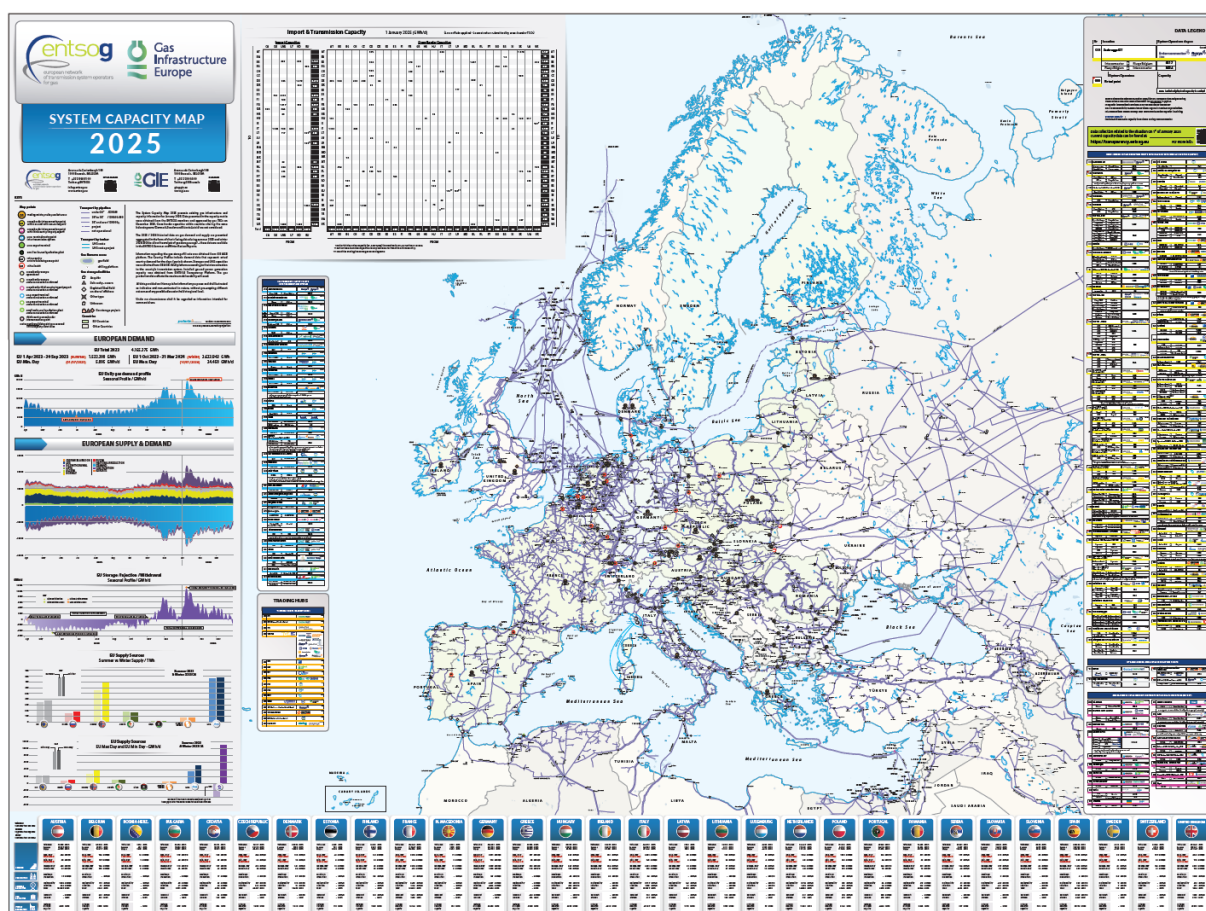
Table 1: EU Natural Gas Imports by Source (2021–2024)

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Year	Pipeline Imports (%)	LNG Imports (%)
2021	70	30
2022	60	40
2023	50	50
2024	45	55

Source: BP Energy Outlook 2023; IEA Gas Market Report Q1 2025

Figure 1: European Gas Pipeline and LNG Infrastructure Map



Source: *ENTSO-G Transparency Platform, 2024* / <https://gie.eu/map-order/product/system-capacity-map-2025/>

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How to cite this article by the APA method:

H.Benhamida, A.Benaissa (2025), Dynamics and Infrastructure of the Natural Gas Market in Europe: Supply, Transport, and Markets, Development and prospection journal for researches and studies Journal, Volume 05 (Number 01), Algeria: Akli Mohand Oulhadj University-Bouira – ALGERIE, pp. 01-16.