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Greece as a Natural Gas Hub: Current Status and Future Developments

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Abstract

In recent years, the European natural gas sector has undergone significant transformation, with notable shifts in trading and pricing mechanisms. Historically, oil indexation dominated gas pricing, but there has been a marked transition towards hub-based pricing models. Gas hubs, whether virtual or physical, have grown in prominence, serving as key marketplaces that enhance transparency and pricing efficiency by facilitating the exchange of gas volumes between buyers and sellers.

Despite these advancements across much of Europe, Southeast Europe continues to face challenges in establishing an efficient market mechanism for gas trading and price discovery. The region's gas exchange is still largely dependent on bilateral agreements, which impedes the development of a more competitive and dynamic market environment. The absence of a robust price discovery mechanism for spot prices further limits market evolution.

Energy security remains a critical concern for the European Union (EU), which is actively working to decrease reliance on external suppliers and promote stable, open, and liquid energy markets. One of the EU's key objectives is the creation of a mature regional natural gas hub in Southeastern Europe. Such a hub would not only support wholesale trading but also provide a platform for both physical and financial transactions, thereby enhancing market competitiveness. However, to realize this goal, initial administrative oversight may be necessary to ensure the hub's effective operation and development.

This thesis aims to assess the potential of the existing Greek gas hub, the Hellenic Trading Point, to evolve into a fully mature regional hub. The study will consider recent developments in the Southeast European gas market, as well as the broader trend towards establishing additional hubs across Europe. The methodology will involve an analysis of the dynamics and characteristics of established European gas hubs, followed by an exploration of the unique features of the Southeast European market. Finally, the study will identify strategies to attract higher volumes and increased participation from market players, ultimately supporting the hub's growth and maturity.

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Introduction

Over the past few decades, the European gas sector has undergone significant transformation, largely driven by evolving EU regulations. These changes have had a profound impact on the trading and pricing of natural gas. While oil indexation previously served as the primary pricing mechanism, there is now a marked shift towards hub-based pricing. Gas hubs, which can be either virtual or physical, have emerged as crucial venues where buyers and sellers can trade gas volumes, effectively serving as marketplaces for natural gas.

The establishment and development of a gas hub are primarily determined by its liquidity, which can be assessed through a combination of both quantitative metrics and qualitative factors. Five key components define liquidity: the number of market participants, the diversity of traded products, the volume of trades, the tradability index, and the churn rate. Additionally, three main indicators play a crucial role: political will, cultural attitudes, and commercial acceptance. Liquidity in European trading hubs is on the rise, and the European Union is actively working to enhance this liquidity further in pursuit of an integrated and interconnected internal energy market.

Greece introduced natural gas into its energy market in 1986, primarily as a means of diversifying energy sources and reducing dependence on oil. This move also positioned Greece more prominently on the European energy map. Additionally, natural gas was seen as a means to help Greece improve its environmental performance in line with EU regulations. However, despite initial positive momentum, natural gas only accounted for a minor share of the Greek energy market—around 0.2%—until 1996, with its use largely confined to power generation.

The situation began to change after the commissioning of Greece's first LNG terminal in Revythoussa in 2000, which marked the beginning of some early attempts at market liberalization. Despite these efforts, gas consumption stagnated as the country plunged into a decade-long economic crisis. Recently, however, there have been developments that suggest a revitalization of the Greek gas market, aligning with the country's broader decarbonization goals. Following Greece's exit from its final bailout program in 2018, the investment climate began to improve, with the natural gas sector being one of the beneficiaries. The long-delayed privatization of the state-owned gas distribution network was completed, with a majority stake sold to a consortium of three major European gas transmission companies. Additionally, in January 2019, the European Investment Bank (EIB) agreed to finance the construction of a new LNG bunkering vessel in Greece, the first of its kind in the Eastern Mediterranean region, further contributing to the development of a Greek gas hub.

To foster competition, Greece has undertaken several initiatives aimed at liberalizing and deregulating its wholesale energy market. A significant step in this direction was the establishment of the Hellenic Energy Exchange (HEnEx) in 2018, which oversees the operation of the Energy Derivatives Market, the Day-Ahead Market, and the Intra-Day Market. HEnEx also launched the Natural Gas Trading Platform, an organized market that operates in accordance with EU regulations, such as the BAL Network Code (Regulation (EU) 312/2014) and REMIT (Regulation (EU) 1227/2011). This platform enhances the operating framework of Greece's wholesale gas market. Participants in the Natural Gas Trading Platform include Transmission Users and DESFA, the Greek natural gas transmission system operator. DESFA engages in trading short-term Standardized Products to balance the National Natural Gas Transmission System. Transactions on the platform are anonymous, with amounts automatically reported to DESFA. HEnEx publishes various price indices based on transactions made on the platform, including Closing Prices, the Next Day Gas Index (HGSIDA), the Intraday Gas Index (HGSIWD), and Buy and Sell Marginal Prices.

This study aims to assess the potential for the Greek gas hub, specifically the Hellenic Trading Point, to evolve into a fully mature hub. This assessment will consider recent developments in the regional gas market, as well as the broader trend of establishing additional gas hubs across Europe. The methodology involves an initial examination of the dynamics and characteristics of established European gas hubs, followed by an exploration of the unique attributes of the Southeast European market. The study will also identify strategies to attract greater volumes and increase participation from market stakeholders, thereby supporting the hub's growth and maturity.

Chapter 1 introduces the concept of a "natural gas hub," while Chapter 2 provides an analysis of European gas hubs and discusses how liquidity is a key indicator of a hub's maturity. Chapter 3 reviews the impact that the creation of a natural gas hub can have on pricing, not only in the countries directly involved but also on a wider scale by setting a benchmark price. Chapter 4 offers an overview of Southeast Europe and Greece as gas transit regions, considering their geographical positions, current and future gas supply-demand scenarios, and ongoing natural gas infrastructure projects. Chapter 5 discusses recent developments at the Hellenic Trading Point and outlines a roadmap for enhancing its maturity. Finally, Chapter 6 summarizes the study's conclusions and suggests the next steps forward.

Chapter 1: The characteristics and requirements of a gas hub

Despite the British gas market having been liberalized for nearly 30 years and the EU having introduced its first Gas Directives nearly 25 years ago, there remains some confusion across parts of Europe about the concept of a "gas hub." There is ongoing debate about whether a gas hub refers to a physical location—such as a terminal, flange, processing plant, or compressor station—or to a virtual point, often situated within a country's gas grid network, known as an Entry/Exit zone or Market Area. Under the Gas Target Model, these Market Areas are playing a crucial role in balancing physical gas volumes, pricing, and facilitating gas trading. This chapter focuses on the commercial, financial, and trading aspects of gas hubs, with an emphasis on their virtual nature.

A key requirement for the successful transition to market-based pricing in the gas sector is the establishment of reliable, transparent, and liquid traded gas markets, which are essential for companies to manage the risks associated with their trading portfolios. As more wholesale contracts are linked to reference indices—such as the Month Ahead Index or Day Ahead Index at the NBP (National Balancing Point) or TTF (Title Transfer Facility)—it becomes increasingly important for newly established gas hubs across Europe to function at a minimum as balancing hubs. Ideally, these hubs should also evolve into centers for risk management. The EU Network Codes and Guidelines serve as crucial tools in achieving the overarching objectives of a single energy market: market integration, non-discriminatory access to infrastructure, effective competition, and efficient market operations.

For a liberalized wholesale market to develop successfully and for a traded gas hub to thrive, it is essential that the industrial, commercial, and residential sectors within a country are fully liberalized. This liberalization fosters competition among suppliers and prompts end users to demand more competitive pricing. As a result, the wholesale sector increasingly relies on traded hubs to manage portfolio risks, which eventually encourages market suppliers to actively participate in these hubs. Contracts in the traded gas market are generally standardized, meaning that all terms and conditions – aside from the delivery period, quantity, and price – are harmonized. These contracts can be traded bilaterally or through exchanges, but they share a common format. This standardization is significant because it centralizes liquidity, and increased liquidity attracts volume, which in turn draws more traders, all of which are essential components of a successful hub.

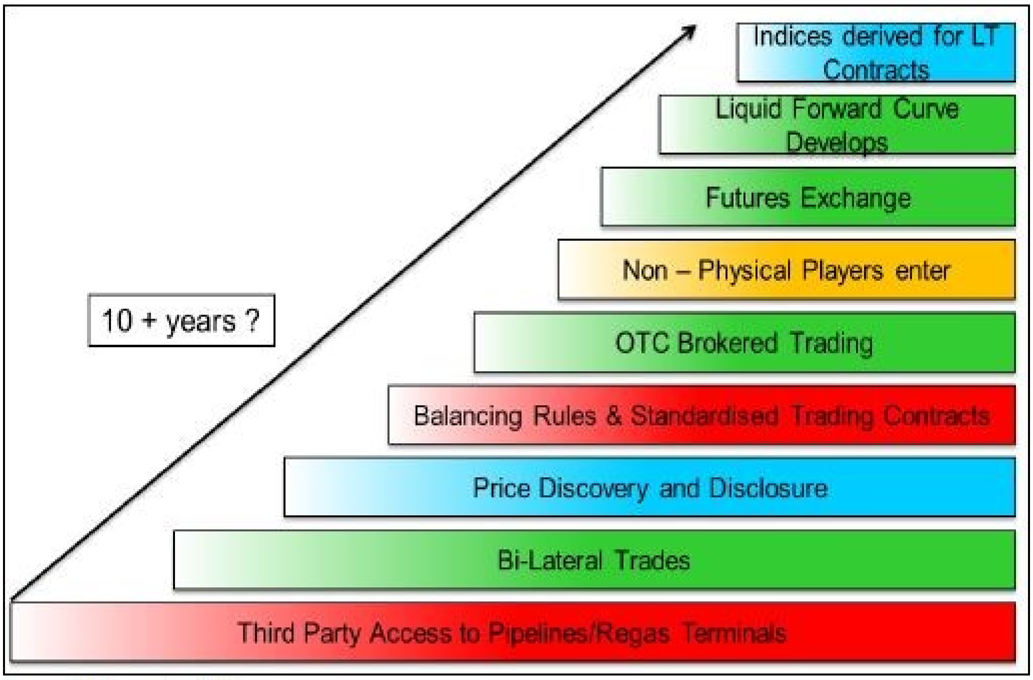
Across Europe, all gas hubs serve as "balancing" hubs, where shippers balance their portfolios close to maturity and at delivery, and where Transmission System Operators (TSOs) physically balance the gas grid, typically on a daily basis. However, "trading" hubs are also used by shippers to manage portfolio risks, often planning up to three years in advance. The most mature and successful hubs effectively function as both balancing and trading hubs, contributing to a stable and efficient gas market.

1.1 The road to maturity

The journey to establish a liquid gas hub is a gradual process that demands both time and a strong commitment from all stakeholders involved. Historical patterns observed in North America, the United Kingdom, and now in north-western Europe, reveal that this transformation can significantly disrupt the market and impose financial challenges on legacy players who once dominated the pre-liberalization environment. Lessons drawn from the evolution of the North American and British markets suggest that this process can span anywhere from 10 to 15 years, a timeline that is currently being mirrored in Continental Europe. For a smooth transition, cooperation among governments, suppliers, and system operators is critical. Markets that either have domestic gas production or are well-supplied by diverse and competitive sources tend to achieve liquid trading hubs more swiftly.

Typically, the transition starts with the introduction of Third Party Access (TPA) to the existing network infrastructure. This often requires legislative reforms to compel established companies to relinquish control over infrastructure capacity and gas supply volumes, thereby creating opportunities for independent entities to enter the market. Concurrently, the establishment of regulations governing the physical operations of the gas industry is necessary, and the adoption of standardized contracts is key to facilitating commercial activities. Bilateral trading often follows, with initial support from brokers who help to create trading opportunities between parties. As these trades become reported in industry publications, they lay the foundation for a transparent market environment. The disclosure of prices is essential for price discovery, which in turn attracts more market participants, including smaller physical traders and the first exploratory steps by financial players. The development of exchange-traded products, such as futures contracts based on underlying physical agreements, broadens market access, particularly for non-physical traders who typically close their positions before contract maturity. As more diverse participants engage in trading within a specific market, a forward curve begins to take shape, serving as a vital tool for risk management. A hub is considered mature when it achieves sufficient liquidity, enabling traders to use specific traded products – such as Day-Ahead or Month-Ahead contracts – as benchmarks for pricing physical gas transactions.

Figure 1: Hub's development "road to maturity" (H. Rogers,2011)



Five key factors are crucial for the successful trading within a gas hub: liquidity, volatility, anonymity, transparency, and traded volumes.

- **Liquidity** is the measure of how easily a specific volume can be traded at a given price without causing significant market fluctuations. The standardization of contract terms plays a pivotal role in concentrating liquidity, thereby enhancing trading efficiency.
- **Volatility** gauges the degree of price fluctuation relative to market activity. Financial markets typically exhibit high liquidity with relatively stable and low volatility. In contrast, energy markets are often characterized by significant volatility, although they can also be highly liquid. These markets are particularly sensitive to external factors that can drive substantial price changes.
- **Anonymity** is fundamental to the integrity of futures trading. The Clearing House acts as the counterparty for all transactions, allowing participants of all sizes to trade without revealing their identities.
- **Market Transparency** is indispensable for the development of a thriving trading market. This entails the prompt dissemination of traded volumes and prices to the public domain, which fosters greater confidence among traders. The availability of accurate, reliable, and timely market data - whether it pertains to official government statistics on energy consumption, Transmission System Operator (TSO) data on physical flows or capacity auctions, or broker and exchange volume and price

information—is critical. While countries like the United Kingdom and the Netherlands have advanced data-sharing practices, other European nations are gradually catching up, showing promising signs of progress.

- **Traded Volumes** refer to the total quantity of gas exchanged within a particular market. This includes over-the-counter (OTC) transactions, exchange trades, or a mix of spot and curve trading, always reflecting the aggregate volume traded in each category.

When it comes to trading activities, spot and prompt contracts are primarily utilized to optimize or balance portfolios close to the time of physical delivery. The forward curve, on the other hand, is typically employed to enhance the financial performance of trading portfolios, whether for hedging or speculative purposes. Most trading is concentrated in the prompt and near curves, with commonly traded contracts including Within-Day (WD), Day-Ahead (DA), Month-Ahead (MA), and contracts covering the first two seasons. There is also trading activity within the mid-curve, driven by price differentials between seasons, although activity significantly declines beyond the three-year mark, primarily due to credit constraints.

The term **"curve"** refers to the time horizon over which trading can occur. This trading curve is divided into several segments:

- **Spot** refers to immediate delivery, typically for today or tomorrow.
- **Prompt** covers all remaining periods within the current month.
- **Near Curve** spans from the front month to the first two seasons.
- **Mid Curve** extends up to approximately two years ahead.
- **Far Curve** encompasses all periods beyond the mid curve, currently extending up to about five years into the future. However, some European gas markets, such as the National Balancing Point (NBP) and Title Transfer Facility (TTF), offer quotes extending as far as ten years.

Short-term trading contracts include Within Day (WD), Day Ahead (DA), Balance of Week (BOW), Weekend (WE), and Balance of Month (BOM), which cover individual days or groups of days. The trading curve, meanwhile, allows for transactions over months, quarters, seasons, and years (both calendar and gas year), providing a range of strategic options across different timeframes.

1.2 ‘Traded’ gas, ‘Contracted’ gas and ‘Exchanged’ gas

The terms surrounding gas trading can often lead to confusion, particularly as different countries have historically approached trading in various ways. However, a more unified understanding has gradually emerged. "Traded" gas refers to the buying and selling of gas at hubs, which can be for physical delivery, financial hedging, or speculative trading. This gas typically represents a standardized product, whether it is traded over-the-counter (OTC) or on exchanges, and is relevant for spot, prompt, or mid-curve maturities. For instance, in the United Kingdom, roughly 50% of the gas consumed is net traded, meaning it is exchanged on the market, while about 20% of the total gas consumption is gross traded. This involves the same volume of gas being bought and sold multiple times before it reaches the end consumer, a phenomenon known as "churn."

In contrast, determining the proportion of gas traded as a percentage of total consumption in different Market Areas across Continental Europe proves more challenging compared to the UK. The Netherlands is an exception, where sufficient market transparency allows for a reliable assessment thanks to frequent and accurate data reporting. For other European countries, gaining insight into the volume of "traded" gas requires direct conversations with market participants. Nonetheless, it is important to recognize that the volume of traded gas generally reflects the level of maturity of each country's gas hub.

"Contracted" gas, on the other hand, refers to gas that has been traded or agreed upon bilaterally for delivery at a hub. This can include both standardized products and bespoke contracts, which may range in duration, typically spanning medium to long terms. In the UK, around half of the consumed gas is contracted, with no churn, as the seller delivers the gas directly to the buyer or through a hub. Contracted gas encompasses both the traditional Long-Term Contracts (LTCs) common in Continental Europe and the newer, shorter-term contracts prevalent in the UK. While Continental European LTCs usually have durations of 20 to 30 years, British long-term contracts tend to last between 8 to 12 years. In North America, any contract extending beyond one year is often considered long-term.

A less frequently discussed concept is gas "exchanged" at a hub, a term sometimes referenced by regulators and Transmission System Operators (TSOs). This practice, although declining, refers specifically to the gas that is physically nominated, delivered to, or withdrawn from a hub. It pertains to the physical or volumetric aspect of gas transactions rather than the financial or pricing components. As markets evolve, the distinction between traded, contracted, and exchanged gas becomes clearer, helping to harmonize practices across different regions.

1.3 Exchange based-trading vs. Over-The-Counter (OTC) trading

Natural gas is traded either bilaterally, over-the-counter (OTC), or centrally on an exchange. A centralized trading mechanism, such as a shared platform, is not used in an over-the-counter market to aggregate bids and offers and allocate trades. OTC trades are nonregulated bilateral transactions in which buyers and sellers negotiate terms privately, often without being aware of current prices available from other potential counterparties and with limited knowledge of trades recently negotiated elsewhere in the market. OTC trading can be done with both standard and customized products.

Exchange-based trading is based on standardized products that are defined by their delivery time. If there is sufficient liquidity in the market, the delivery date can range from a few days to several years in the future. The more distant the delivery date, the more liquid the market is thought to be. A spot market and a futures market can both operate in OTC markets and exchanges. On the spot market, delivery is instant. It contrasts with futures markets, where delivery is scheduled for a later date and may extend for years.

The primary distinction between OTC trading and exchange trading is that trading on the exchange occurs anonymously, and the counterparty risk is managed by the exchange, which means that the exchange – or its clearinghouse – guarantees that the other side of the transaction performs to its obligations. Through the price signals it provides, exchange-based trading also increases transparency in the natural gas market. On gas hubs, OTC is still the preferred trading method. The main benefits of OTC trading are lower costs (e.g., no clearing fees) and customized products, which are widely used by suppliers to accommodate each consumer's timing, volume, and so on. Transactions on exchanges are clearer and safer, but their fees are often prohibitively expensive for small businesses. Exchanges require a high level of standardization and liquidity in the products traded, which can make it difficult for many energy providers to find the customized products they require to manage their risks.

However, because the share of exchange trading has been steadily increasing, exchanges are expected to continue to develop and play an important role in natural gas trading in Europe, alongside OTC trading.

1.4 Physical vs. Virtual hubs

A gas hub can either be a physical location where multiple pipelines converge, like Zeebrugge, or a virtual point within a pipeline system, such as the National Balancing Point (NBP) in the UK. A physical hub functions as a tangible site where natural gas pipelines intersect, allowing for the trade of gas as well as serving as transit points and storage facilities.

However, hubs are not limited to physical intersections; they can also be virtual platforms designed for trading natural gas in financial markets. These virtual hubs provide access to numerous participants across a broader geographic area, potentially covering an entire country or trans-regional zones. Unlike physical hubs, which can only trade gas physically passing through a specific location (thereby introducing higher risks), virtual hubs enable the trade of any gas that has paid the requisite network access fee, offering a more flexible and expansive trading environment.

The Oxford Institute for Energy Studies (OIES) offers an alternative classification system for EU gas hubs, organizing them into trading hubs, transit hubs, and transition hubs based on their level of market development. Trading hubs are well-established, mature platforms where market participants can efficiently manage their gas portfolios. According to OIES, only the UK's NBP and the Dutch Title Transfer Facility (TTF) qualify as mature trading hubs in Europe. Transit hubs, on the other hand, are physical locations where the primary function is the physical trading of natural gas to facilitate its onward transportation. Notable examples of transit hubs in Europe include the Central European Gas Hub (CEGH) in Austria and the Zeebrugge hub (ZEE) in Belgium.

Transition hubs represent virtual hubs that are still in the early phases of development but have already started to establish benchmark prices for natural gas within their respective national markets. These include the German hubs Gaspool Balancing Services (GPL) and NetConnect Germany (NCG), as well as France's Points d'Échange de Gaz (PEGs) and Italy's Punto di Scambio Virtuale (PSV).

The emergence of these hubs has also been instrumental in the development of gas exchanges, where various services such as spot trading, forward markets, and variable derivatives are offered. These exchanges are not limited to gas; they often handle other commodities like electricity and coal as well. This diversification underscores the significant role hubs and exchanges play in the broader energy market landscape.

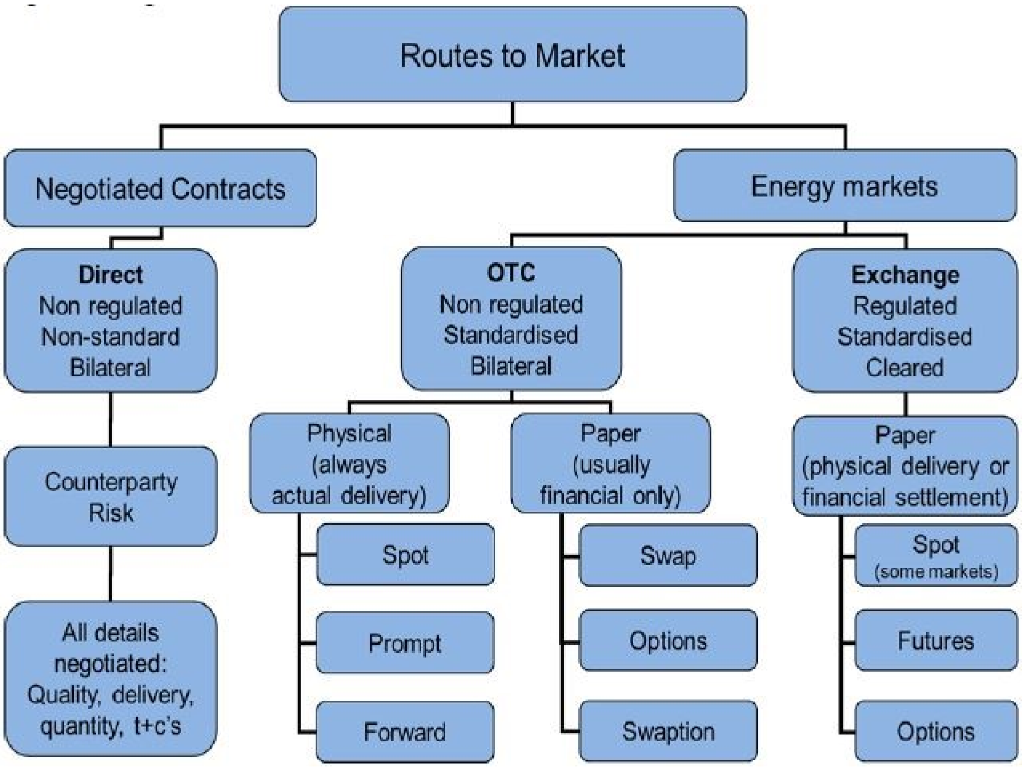
1.5 Routes to market

After outlining the path to hub maturity, it's crucial to explore the motivations behind why a company might engage in trading. Businesses participate in trading for several key reasons: to balance a physical gas portfolio, to hedge against financial risks, or to speculate on market movements. Understanding these motivations is essential for grasping the dynamics of trading in both regulated and unregulated markets.

The specific reason for trading will guide the choice of market – whether to engage in the "paper" market, which involves financial instruments, or the physical market, where actual gas is traded. Companies also need to decide whether to use regulated markets with standardized products or unregulated markets with more customized options. Trading instruments vary widely, ranging from bilaterally negotiated contracts to standardized physical deals traded over-the-counter (OTC). Additionally, companies may use futures markets and other cleared transactions to manage risk or engage in financial trades such as swaps. In some markets, there is even the option to trade derivatives like options, which can be either cleared or bilateral, and can involve physical or financial transactions.

Each of these trading instruments serves different purposes and offers various levels of risk management, liquidity, and flexibility, depending on the company's specific trading goals. Whether the focus is on balancing physical supplies, hedging financial exposure, or taking speculative positions, the chosen trading route will significantly impact the strategy and outcomes in the natural gas market.

Figure 2: Diagram of the "routes to market" (Heather, 2010)



Chapter 2: Natural gas hub analysis

The evolution of European natural gas markets has been profound over recent decades. Compared to their American counterparts, European gas hubs are relatively nascent and less established. In North America, the Henry Hub in Louisiana acts as the benchmark for the most liquid gas market globally, setting the standard for pricing across the region. Historically, the European gas market was dominated by long-term contracts with producers, often located outside the EU, specifying precise volumes and delivery points along gas transmission networks. However, since the mid-1990s deregulation, there has been a significant shift. The gradual liberalization of gas markets across Europe has fostered the growth of trading and spot markets, with increasing participation and traded volumes complementing traditional over-the-counter (OTC) transactions.

Recent years have seen dramatic fluctuations in the European gas markets. The COVID-19 pandemic in 2020 led to a sharp decline in gas demand, followed by a surge in prices as global demand rebounded in mid-2021. The situation was further exacerbated by geopolitical tensions, particularly the Russian invasion of Ukraine in early 2022, which resulted in a 56% reduction in Russian pipeline gas supplies to Europe. This backdrop is further complicated by ongoing debates over the Green Transition and the gradual phase-out of carbon-based energy sources, including natural gas.

To evaluate the maturity and development of European traded gas hubs, two analytical approaches are employed. The first involves an objective assessment of trading data from available hubs, analyzing five critical elements to gauge their level of market development. This method, while detailed, only covers up to nine of the 28 EU Member States with notable gas trading activities. The second approach uses a more subjective evaluation, focusing on three key indicators: political commitment, cultural attitudes, and commercial acceptance. This assessment aligns with the EU's Gas Target Model and the Commission's vision for a unified Single Energy Market, providing a broader view of each hub's progress toward achieving a fully liberalized and liquid market.

2.1 European natural nas hubs overview

The aim of the second chapter is to provide a nuanced understanding of the factors that contribute to the uniqueness of each gas hub and how they collectively shape the broader European energy landscape. The most important gas hubs are presented in chronological order below:

NATIONAL BALANCING POINT (NBP)

The **National Balancing Point (NBP)** in the UK, established in 1996, is Europe's oldest and most liquid natural gas trading hub, frequently compared to the U.S.'s Henry Hub, the benchmark for natural gas futures on the New York Mercantile Exchange (NYMEX). Unlike physical trading points, the NBP is a virtual trading location where transactions occur through the On-the-Day Commodity Market (OCM) trading system, managed by ICE-Endex. This system allows gas offers or bids at specified prices, with ICE-Endex acting as the counterparty in over-the-counter (OTC) trades and responsible for submitting these trades to the National Grid, the UK's transmission system operator (TSO). In the NBP, about 70% of trading volume is OTC, with the remaining 30% handled by ICE futures.

The NBP was developed to help balance the UK's gas system as dictated by the Network Code, which outlines the rules for accessing the British pipeline grid. Shippers at NBP must declare the quantities of gas entering or leaving the network rather than the physical routes. The National Grid is tasked with daily system balancing, a unique setup only mirrored by the Dutch Title Transfer Facility (TTF). The UK has three main pipeline links to the European Union: the BBL from Bacton to the Netherlands, the Interconnector UK from Bacton to Belgium, and the Irish Interconnectors from Scotland to Ireland and the Isle of Man. The Interconnector pipeline, connecting the UK and Belgium, was a significant development in the liberalization of the UK gas market, enabling price interaction with the continental market.

ZEEBRUGGE (ZEE)

The Zeebrugge (ZEE) hub in Belgium is a critical physical gas trading hub in the EU, with a throughput capacity of 48 bcm per year, handling gas from Norway, the Netherlands, Algeria, and the UK. This hub connects to the UK via the Interconnector and to Norway's gas fields through the Zeepipe. The Zeebrugge hub plays a crucial role in European gas flows, linking the east/west axis from Russia to the UK and the north/south axis from Norway to Southern Europe. It is a key transit point for gas traveling to various European countries, and its prices are closely linked to those at the NBP and the TTF.

TITLE TRANSFER FACILITY (TTF)

The Title Transfer Facility (TTF) in the Netherlands, launched in 2003 by Gasunie Transport Services (GTS), is a virtual trading hub that has become the central point for natural gas trading in the Dutch system. The TTF allows participants to transfer gas within the system without physical movement, and it has grown to be the largest gas hub in Continental Europe by traded volume. The TTF's spot trading is managed by ICE Endex, and it plays a pivotal role in the European gas market, with its prices serving as a key indicator for the region.

PUNTO DI SCAMBIO VIRTUALE (PSV)

Punto di Scambio Virtuale (PSV) is Italy's primary gas trading point, established in 2003 and operated by Snam Rete Gas. The PSV facilitates daily gas transactions, matching supply and demand, with futures trading managed by GME, Italy's energy market operator. Italy's gas market, heavily reliant on gas for electricity generation, is diversely supplied, with ENI dominating imports, production, and transport. The PSV has seen prices converge with those at TTF as infrastructure issues have been resolved.

POINTS D' ECHANGE DE GAZ (PEGS)

The French gas market operates through Points d'Échange de Gaz (PEGs), virtual trading points within three balancing zones: PEG Nord, PEG Sud, and PEG TIGF. Managed by Gaz de France, these PEGs allow for gas trading through OTC agreements or on the Powernext exchange. However, due to low liquidity, PEGs have primarily served as balancing points rather than active trading hubs.

CENTRAL EUROPEAN GAS HUB (CEGH)

The Central European Gas Hub (CEGH) in Austria, headquartered in Vienna, is a significant hub for east-west gas flows, particularly Russian gas entering Western Europe. CEGH operates both spot and futures markets and is central to gas trading in Austria and its neighboring countries, linking major gas flows from Russia, Central Asia, and the North Sea.

NETCONNECT GERMANY (NCG)

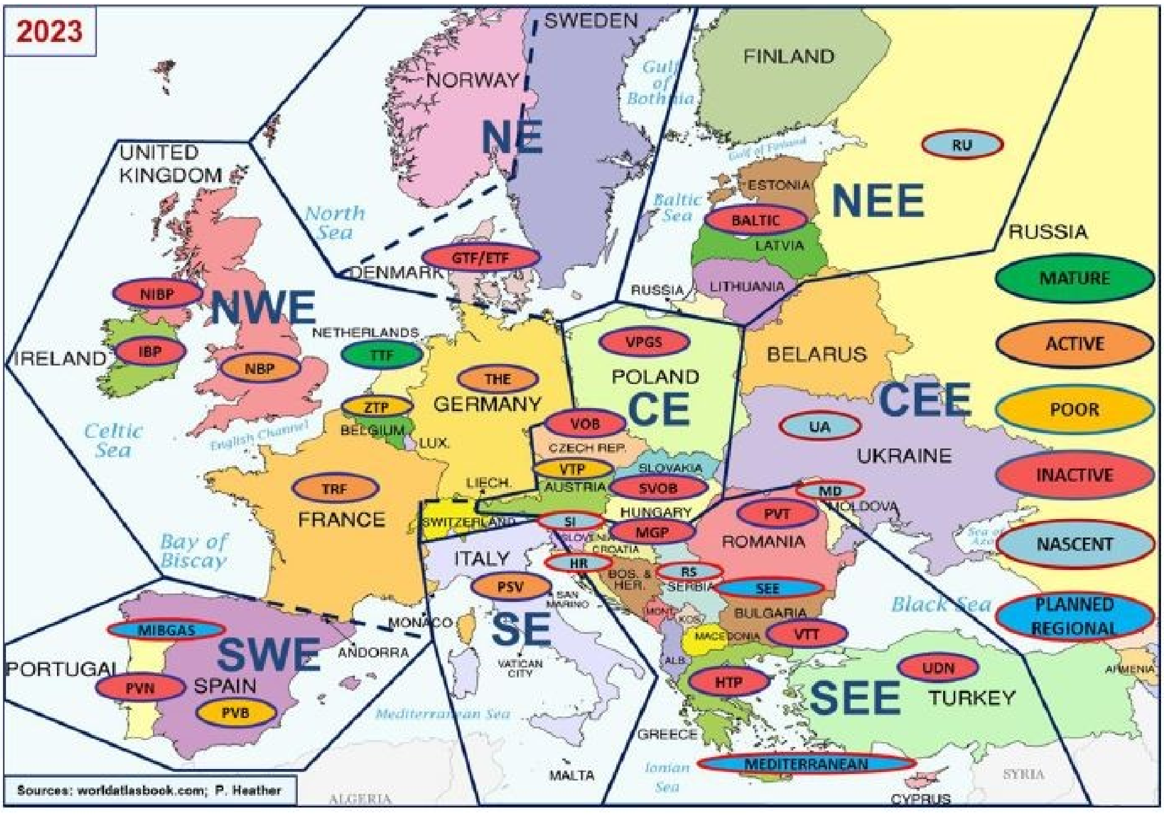
NetConnect Germany (NCG) is Germany's largest gas grid operator, managing a vast network that links Germany with other European countries. Germany's extensive pipeline infrastructure and significant storage capacity make it a crucial transit hub for gas traveling from Russia and Norway to other European markets.

GASPOOL BALANCING SERVICES

Gaspool, serves Northern Germany and operates similarly to NCG but functions more as a physical hub with a focus on balancing services.

These hubs form the backbone of Europe's natural gas market, each playing a unique role in the continent's energy landscape by facilitating gas trade, balancing supply and demand, and influencing regional and global gas prices. Figure 3 lists all European gas hubs that were operational by the end of 2023. The hubs are categorized by color to indicate their status as 'mature', 'active', 'poor', or 'inactive'. Currently, the Dutch TTF is the only hub classified as Mature. The British NBP lost its Mature status in 2021 and is now considered Active, along with three other hubs: Germany's THE, France's TRF, and Italy's PSV. The Austrian VTP, Spanish PVB, and Belgian ZTP are categorized as poor. All other hubs are classified as Inactive, with the Belgian ZEE ceasing operations in September. Additionally, there has been a shift in terminology from 'Planned National' to 'Nascent' for new hubs in Slovenia, Croatia, Serbia, and Moldova. However, due to insufficient data, these Nascent and some Inactive hubs have not been included in the analysis.

Figure 3: European gas regions, markets and hubs: (Heather, 2024)



2.2 Liquidity analysis

This section presents two distinct analytical approaches to assess and categorize the development of European traded gas hubs, focusing on their progression towards becoming fully liberalized, mature, and liquid markets. The first approach is an objective analysis based on available traded data, providing a comprehensive and quantifiable assessment of these hubs. This method evaluates the hubs against five Key Elements, offering a structured framework that facilitates clear and actionable conclusions.

In contrast, the second approach is more subjective, evaluating each hub's development in the context of the European Union's Gas Target Model and the broader vision for a Single Energy Market as outlined by the European Commission. This analysis is grounded in three Main Indicators: political will, cultural attitudes, and commercial acceptance within each market. This subjective assessment provides insight into the non-quantifiable aspects of market development, such as regulatory environments, stakeholder engagement, and the degree of market integration within the EU's energy framework. By combining these two methods, the analysis offers a holistic view of the progress and challenges facing European gas hubs on their path to full market maturity.

2.2.1 The 5 Key Elements

To evaluate the depth, liquidity, and transparency of Europe's traded gas hubs, an analysis is conducted based on five essential Key Elements, contingent upon the availability of relevant data. The five key elements under consideration include:

1. **Market Participants**: Identifying who is actively trading within each hub.
2. **Product Range**: Analyzing the types of products being traded at each hub.
3. **Volume and Time Periods**: Assessing the volume of gas traded and the duration over which these trades occur.
4. **Tradability Index**: Evaluating the ease with which trades can be conducted.
5. **Churn Rates**: Measuring the frequency of trading relative to the physical delivery of gas, with churn rate potentially being the most critical indicator.

All of these elements are crucial for a comprehensive assessment, but the churn rate stands out as particularly significant. A thorough analysis requires the examination of at least these five criteria; however, consistent data across all hubs is not always available. Despite this limitation, the results derived from analyzing these elements can effectively categorize the hubs into three distinct groups: 'mature,' 'active,' and 'inactive.' These classifications help in understanding the level of market development and operational effectiveness within each gas hub.

Key element 1: Market participants

The first Key Element to consider when assessing a gas hub's development is its market participants. The number and diversity of companies actively trading at a hub are crucial indicators of the market's maturity and attractiveness. A higher number of participants suggests a welcoming environment for traders and reduces the risk of market domination by any single entity. To accurately gauge participation, it's important to look beyond just the total number of companies registered to trade at a hub, whether over-the-counter (OTC) or on an exchange. Factors such as the number of 'active' traders, the types of participants (whether physical, financial, or administrative), and the potential for duplicate entries by related entities must also be considered.

An accurate assessment of market participants requires scrutiny. This includes examining lists of participants, shippers, and exchange members to eliminate duplicates - often, only one trading entity will be active within a group of companies with common ownership. The focus should be on the number of independent, active participants since more frequent trading activity correlates with greater market liquidity. Ideally, the types of participants should also be identified, as this provides further insight into the hub's operational dynamics.

However, this analysis demands some subjective interpretation, especially since definitions of 'active' participants can vary. Regulators, Transmission System Operators (TSOs), exchanges, and trade publications may report different figures based on their own criteria for defining market participants and active traders. For European gas markets, it's generally accepted that a minimum of ten active companies is necessary to foster market activity and liquidity. Yet, defining what constitutes an 'active' participant is inherently subjective. Not all Market Areas have formalized lists of registered traders, and there is currently no standardized data across Europe regarding participant definitions or publication. The implementation of REMIT (Regulation on Wholesale Energy Market Integrity and Transparency) is expected to standardize this over time.

It's also important to note the limitations of relying on data from brokers and market participants. While OTC brokers can provide a count of active traders, their market coverage might be limited. Moreover, participants may be more active in certain hubs than in others. The focus on active traders is crucial because these are the participants that enhance liquidity, foster competitive trading environments, create tighter bid/offer spreads, and reduce the risk of market manipulation.

In a basic commodity market, physical traders such as producers, wholesalers, retailers, and consumers typically form the core. As the market evolves, administrative participants, including TSOs and storage operators, are added. Over time, financial players such as banks, hedge funds, and proprietary traders enter the market, using OTC and exchange products to hedge, manage risk, and speculate. A high proportion of financial players is often a sign of a liquid, mature market and reflects confidence in the market's stability and growth potential.

The methodologies applied in table 1 are as follows: For (S/P/M), green indicates scores of 60 or higher, amber represents scores below 60, red signifies scores below 25, and brown indicates scores below 10. For (Q/S/Y), green represents scores of 20 or above, amber for scores below 20, red for scores below 10, and brown for scores below 5. In the (Hub Score) category, the scoring is based on a combination of 1x SPM and 2x QSY, where green indicates a total score of 100 or more, amber for scores below 100, red for scores below 45, and brown for scores below 10. Mature hubs are highlighted in green, while active hubs with developing depth, liquidity, and transparency are shown in amber. Poor hubs, which are not yet deep, transparent, or liquid, are marked in red.

In 2023, trading activity saw a significant uptick following two challenging years for gas trading, which in turn drew more participants to the market. Table 1 highlights the number of 'active' participants at each selected hub, with greater participant activity generally leading to increased market liquidity. The methodology used prioritizes curve trading over spot trading, as the former is typically employed for risk management and hedging of physical contracts by participants.

Table 1: Market participants of European gas hubs in 2023 (Heather, 2024)

2023	OTC Active Traders*				
HUB	Hub Score^		S/P/M**	Q/S/Y***	Hub Score^
	2021	2022	2023	2023	2023
TTF	164	275	80	60	200
NBP	142	127	55	40	135
THE	110	187	40	25	90
TRF	40	116	37	19	75
PSV	92	96	28	20	68
VTP	70	125	26	16	58
ZTP	26	76	27	14	55
PVB	45	52	20	13	46
VOB	27	50	22	11	44
ZEE	20	13	5	4	13

* The estimated number of traders who regularly trade.
** Spot / Prompt / Months contracts; *** Quarters / Seasons / Years contracts.
^ Hub score calculated as (1xS/P/M) + (2xQ/S/Y).

Key element 2: Traded products

When comparing traded markets and assessing their relative success, it's essential to focus on the range of products available for trading and observe where transactions are occurring along the traded curve. This is crucial because only hubs that offer robust risk management tools are likely to evolve into benchmark hubs that set market prices. Benchmark hubs, in turn, are better positioned to offer a variety of risk management products, creating a positive feedback loop – a pattern observed in other global commodity markets. Essentially, liquidity begets liquidity, fostering market success, boosting churn rates, and enabling the market to mature into a reliable source of reference prices.

The traded products table (Table 2) is particularly insightful, as it outlines the various products available for trade and indicates their relative 'popularity' across different hubs using a color-coded system. The table is divided into two main sections: the OTC market on the left and the exchange market on the right. The product categories span spot and prompt contracts, months, quarters, seasons, calendar years, gas years, and include columns for 'OTC clearing' and 'options' (covering both OTC and exchange).

To assess the relative significance of the traded products, several methods are employed. First, the absolute volumes of each product traded in each hub are considered. Then, a scoring system is applied to categorize the OTC and exchange trading columns, as well as the hubs column. The absence of recorded volumes or the unavailability of a product is marked in grey. The color codes are then assigned point values for score calculation:

- Green = 4 points
- Amber = 3 points
- Blue = 2 points
- Red = 1 point
- Grey = 0 points

For the OTC column:

- There are 9 product categories, so the maximum possible score is 36 points (4 points x 9 categories).
    - Green: ≥24 points
    - Amber: <24 points
    - Blue: <14 points
    - Red: <9 points

For the Exchange column:

- There are 7 product categories, so the maximum possible score is 28 points (4 points x 7 categories).
    - Green: ≥16 points
    - Amber: <16 points
    - Blue: <10 points
    - Red: <6 points

For the Hubs column (using a three-color coding system):

- The scores from the OTC and Exchange columns are combined, yielding a total score out of 64.
    - Green: ≥42 points (66% or more)
    - Amber: <42 points (less than 66%)
    - Red: <16 points (less than 25%)

This scoring system provides a clear and quantitative method for evaluating the relative development and success of various gas hubs based on the products they offer and the levels of trading activity observed across these different products.

Table 2: Traded products of the European gas hubs in 2023 (Heather, 2024)

2023 Product evaluation based on absolute volumes* HUB	SCORE/56	OTC	SCORE / 28	CLEARING	WD DA	BOW W/E WDNW BOM	MA MONTHS	QUARTERS	SEASONS	YEARS (CAL + GAS)	EXCHANGE	(% SHARE)	SCORE / 28	BALANCING TRADES	SPOT PROMPT	FUTURES MONTHS	FUTURES QUARTERS	FUTURES SEASONS	FUTURES YEARS	OPTIONS MONTHS
TTF	49	Y	24	Y	Y	Y	Y	Y	Y	Y	ICE EEX CME	93 >6 <1	25	Y	Y	Y	Y	Y	Y	Y
NBP	40	Y	22	Y	Y	Y	Y	Y	Y	Y	ICE EEX CME	>99 <1 0	18	Y	Y	Y	Y	Y	Y	Y
THE	35	Y	18	Y	Y	Y	Y	Y	Y	Y	EEX ICE	>98 <2	17	N	Y	Y	Y	Y	Y	Y
TRF	26	Y	13	Y	Y	Y	Y	Y	Y	Y	EEX ICE	>99 <1	13	N	Y	Y	Y	Y	Y	N
PSV	25	Y	16	Y	Y	Y	Y	Y	Y	Y	GME ICE EEX	53 31 16	9	Y	Y	Y	Y	Y	Y	Y
VTP	21	Y	11	Y	Y	Y	Y	Y	Y	Y	EEX ICE	>99 <1	10	N	Y	Y	Y	Y	Y	N
PVB	15	Y	7	Y	Y	Y	Y	Y	Y	Y	MIB EEX	66 34	8	N	Y	Y	Y	Y	Y	N
ZTP	14	Y	7	Y	Y	Y	Y	Y	Y	Y	EEX	100	7	Y	Y	Y	Y	Y	Y	N
VOB	12	Y	7	Y	Y	Y	Y	Y	Y	Y	EEX	91 9	5	N	Y	Y	Y	Y	Y	N
ZEE	4	Y	3	Y	Y	Y	Y	Y	Y	Y	EEX	100	1	N	Y	Y	Y	Y	Y	N

*KEY: GREEN: =/>600TWh | AMBER: <600TWh | BLUE: <250TWh | RED: <50TWh | GREEN: =/>500TWh | AMBER: <500TWh | BLUE= <100TWh | RED: <30TWh

GREY: No volumes

Hubs column based on OTC + Exchange 'score'/56; OTC column based on 'score'/28; Exchange column based on 'score'/28

ICE=ICE or ICE/Endex | EEX=EEX | CME=CME Europe | MIB=MIBGAS | Y=AVAILABLE | N=NOT AVAILABLE

The variety of products available for trading and the volumes at which they are traded serve as key indicators of a hub's level of maturity. These factors reveal whether a market is primarily used for balancing purposes or for risk management. In 2023, TTF once again leads the rankings with a score of 49/56, maintaining the same score it has held for the past three years. Most individual product categories for TTF are marked as 'green,' indicating that the OTC volume exceeds 600 TWh and the exchange volume surpasses 500 TWh. The remaining hubs have stayed within the same color categories they have occupied since 2020. Four hubs – NBP, THE, TRF, and PSV – showed an improved score in 2023 compared to the previous year, while three hubs – VTP, ZTP, and ZEE – saw a decline, and two hubs – PVB and VOB – remained unchanged. This year, the top five hubs (TTF, NBP, THE, TRF, PSV) scored above the average, with VTP slightly below that threshold. The Spanish, Belgian ZTP, and Czech hubs scored significantly lower, and the Belgian ZEE received a score of just 4/56, reflecting its limited trading activity to spot products before ceasing operations.

Key Element 3: Traded volumes

Traded volumes, identified as the third Key Element, provide a transparent reflection of market dynamics. Regardless of the number of participants or the diversity of products available, the volume of trades offers critical insights into the evolution of a market, specifically within the context of gas hubs. The churn rate (discussed in more detail later) is a key metric that emerges from the relationship between traded volumes and the overall market size. This metric is arguably the most crucial in assessing the effectiveness of a traded market. Typically, markets with significantly high traded volumes exhibit a robust churn rate, a broad spectrum of participants, and are generally resistant to price manipulation.

Reports from various sources – such as regulators, TSOs, trade media, brokers, and exchanges – frequently highlight traded volumes, but these reports often concentrate exclusively on either the OTC market or exchanges. In this analysis, the focus is on total traded volumes, encompassing both OTC and exchange trades, including options and spread transactions where applicable. Careful attention is given to avoid 'double counting' that can occur when OTC transactions are transferred ('given up') to exchanges. This approach does not specify the location of the trades or their maturities; those details are covered in the earlier section on Traded Products.

High traded volumes are generally indicative of a liquid market with a diverse participant base; depending on the size of the underlying physical market, this often correlates with a high turnover rate. The methodology applied in this table 3 is as follows: For volumes, green represents values of 5000 TWh or higher, amber indicates values below 5000 TWh, red marks values under 1000 TWh, and brown denotes volumes less than 100 TWh. The hubs are categorized based on their maturity: green for mature hubs, amber for active hubs that are developing depth, liquidity, and transparency, red for hubs that are underdeveloped in these aspects, and brown for illiquid hubs.

Table 3: Traded Volumes of European gas hubs in 2023 (Heather, 2024)

2023		TOTAL TRADED VOLUMES* (TWh)						
HUB		2008	2011	2021	Δ% =>	2022	Δ% =>	2023
TTF		560	6295	53430	-19	43135	+51	64980
NBP		10620	18000	6640	-5	6335	-2	6185
NCG	THE	EST.215	880	3155	+5	3305	+12	3710
GPL		EST.145	310					
TRF		PEG N 185	PEG N 430	855	+66	1415	+18	1675
PSV		160	185	1155	-19	940	+33	1275
VTP		CEGH 165	CEGH 170	920	-25	685	+0.5	690
ZTP		n/a	n/a	235	+138	560	-16	470
PVB		n/a	n/a	170	+61	260	+29	335
VOB		n/a	n/a	95	-5	90	+3	90
ZEE		500	870	80	-56	35	-86	5

*rounded to nearest 5TWh; not the same data sources in all years.

A quick look at Table 4 reveals that the Dutch TTF hub dominates with the largest traded volumes, encompassing all products across the entire curve. After a slight dip in 2022, trading at TTF surged by 51% in 2023, marking the highest growth among all hubs that year. This increase is partly due to the rising levels of LNG imports into the Netherlands, similar to the trend observed at the French hub. TTF's volumes now exceed the combined total of all other hubs by more than four times; they are over ten times larger than the British NBP, the second most traded hub, over 17 times larger than Germany's THE hub, despite Germany being Europe's largest gas consumer, and nearly 40 times greater than the French TRF.

The Belgian ZTP hub saw a remarkable 138% increase in traded volumes in 2022, but in 2023, volumes declined by 16%, the second largest drop after the Belgian ZEE hub, which ceased trading in September 2023. The British NBP experienced a minor 2% decline, while all other hubs saw varying degrees of improvement. The data clearly illustrate the significant disparities among European hubs, with TTF solidly in the lead. The British NBP, despite its steady decline since 2016, remains the second-largest hub in Europe. Germany’s NCG maintained relatively stable performance through 2021, with the GPL merger boosting THE volumes post-October 2021. The Italian PSV has shown a steady rise, despite a slight downturn from 2020 to 2022, while Austria's VTP has gradually increased from a lower base, although it has plateaued since 2020. The French PEG Nord/TRF has displayed inconsistent performance, but has seen growth in 2022 and 2023, though France remains behind Germany by a similar margin.

In concluding this section on traded volumes, Table 4 presents the total volumes traded at the 'emerging' hubs, although the second column reveals that some of these hubs have actually been operational for several years. Previously have been highlighted the unique circumstances surrounding the Polish VPGS and Danish GTF/ETF hubs. At VPGS, while total volumes saw a slight increase in 2023, these were primarily trades between the incumbent supplier PGNiG and its distribution and retail subsidiaries, with no OTC trades reported. In Denmark, OTC trades at the GTF hub are mainly conducted by shippers adjusting or balancing their portfolios, but none were recorded. At the ETF exchange, there was no curve trading, and the spot trading recorded was largely related to balancing operations, with higher volumes likely due to the completion of the Baltic Pipe project.

In 2023, all the hubs listed experienced volume growth, with the exception of Romania's PVT hub, which saw a second consecutive annual decline of 40%. This drop followed the introduction of a harsh 98% tax on wholesale gas and electricity transactions in 2022. Meanwhile, the newly established Portuguese PVN hub, although still ranking at the bottom in terms of volume, recorded a slight increase in its second year of operation. The Greek gas hub also displayed significant progress, tripling its volume year-over-year to reach 9.03 TWh, despite no over-the-counter (OTC) trades being reported. Slovakia's SVOB hub remains the only emerging hub trading solely OTC, with its volume surging by 148% to 4.05 TWh in 2022. Notably, Bulgaria's VTT hub saw a remarkable increase in trading volume, rising 225% from its 2022 level of 14.01 TWh.

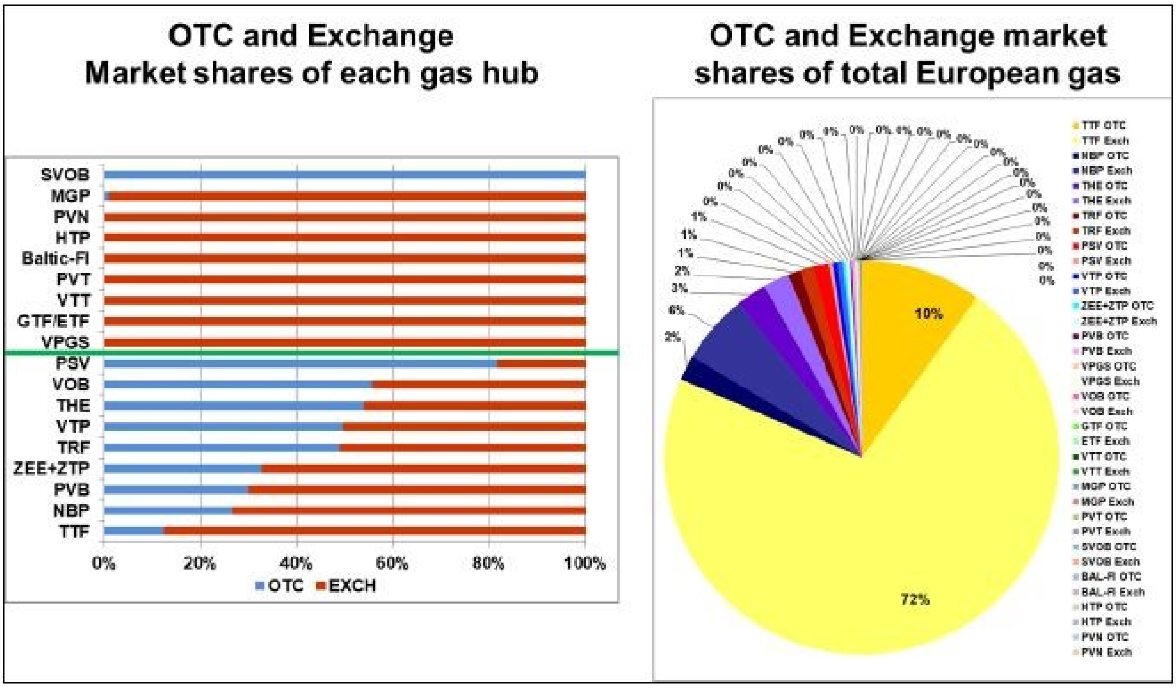
Table 4: Traded Volumes at emerging gas hubs in 2023 (Heather, 2024)

2023		EMERGING HUBS TRADED VOLUMES (TWh)						
HUB	Started	OTC			EXCHANGE			TOTAL
		PRMT	CURVE	TOTAL	SPOT	CURVE	TOTAL	
VPGS	2014	No activity reported			20.75	122.86	143.62	**143.62**
GTF/ETF	2004/08	No activity reported			52.78	Nil	52.78	**52.78**
VTT	2020	No activity reported			14.98	30.51	45.50	**45.50**
MGP	2010	n/a	n/a	0.25	29.66	0.05	29.71	**29.96**
PVT^	2020	No activity reported			11.80	5.97	17.77	**17.77**
SVOB	2016	n/a	n/a	10.05	no exchange trading			**10.05**
Baltic-FI*	2012-20	No activity reported			8.36	0.73	9.10	**9.10**
HTP**	2018	No activity reported			9.03	n/a	9.03	**9.03**
PVN	2021	No activity reported			Only WD,DA,ID			**0.17**

^total physical trades transacted on the Romanian Commodity Exchange (BRM) but not necessarily conducted at the PVT.
*the Baltic-Finland market area, as defined by the GET Baltic exchange, being the sum of the LT/LV-EE/FI Market Areas.
**HEnEx's Gas Trading Platform finally went live 21st March 2022; prior to this, all trades were 'balancing trades' on the Desfa platform.

In recent years, particularly since 2021, there has been a significant shift in gas markets from OTC trading to exchange-based trading. As illustrated in Figure 4, which compares the shares of OTC and exchange trading volumes across the major hubs in Table 4, exchange trading has come to dominate the market. In 2023, exchange trading accounted for 82% of all gas trades in Europe. Some emerging hubs no longer engage in OTC trading at all, and Poland has similarly moved away from it for several years. Denmark, which previously traded OTC, saw no such trades in 2023, while Hungary's MGP hub recorded only a minimal amount of OTC activity.

Figure 4: OTC/Exchange market shares (Heather, 2024)



<u>Key Element 4: Tradability index</u>

The ICIS Tradability Index is calculated by ICIS for 13 European gas hubs and the Turkish UDN. This Index assesses the "bid-offer spread typically available daily to all interested counterparties" across 10 different contracts. The methodology attributes one point for each instance where bid-offer points of less than 0.5 €/MWh and less than 0.3 €/MWh are available, with a maximum possible score of 20 points. While the Tradability Index provides valuable insights, it does not serve as a standalone indicator of a market's depth, liquidity, or transparency. Instead, it should be viewed as a complementary metric that, when combined with other indicators, helps to provide a fuller picture of a hub's development.

This is because the Index focuses solely on the bid-offer spread, without accounting for the market's depth at those quoted prices. While a narrow bid-offer spread is generally a positive sign, its significance diminishes if only a limited volume is traded at the quoted prices. Therefore, while the Index is useful, it must be interpreted alongside other key elements that measure market depth, liquidity, and transparency.

To extract meaningful insights from the Tradability Index, it is crucial to examine its trends over time, analyze the actual scores, and compare them with other metrics. In practice, a score of 18/20 or higher suggests that the hub in question has sufficient liquidity. A score between 14/20 and 17/20 indicates potential and warrants further investigation using additional metrics. However, a score below 14/20 generally holds less significance and may indicate limited tradability.

Figure 5: Tradability Index of European gas hubs in 2023 (Heather, 2024)

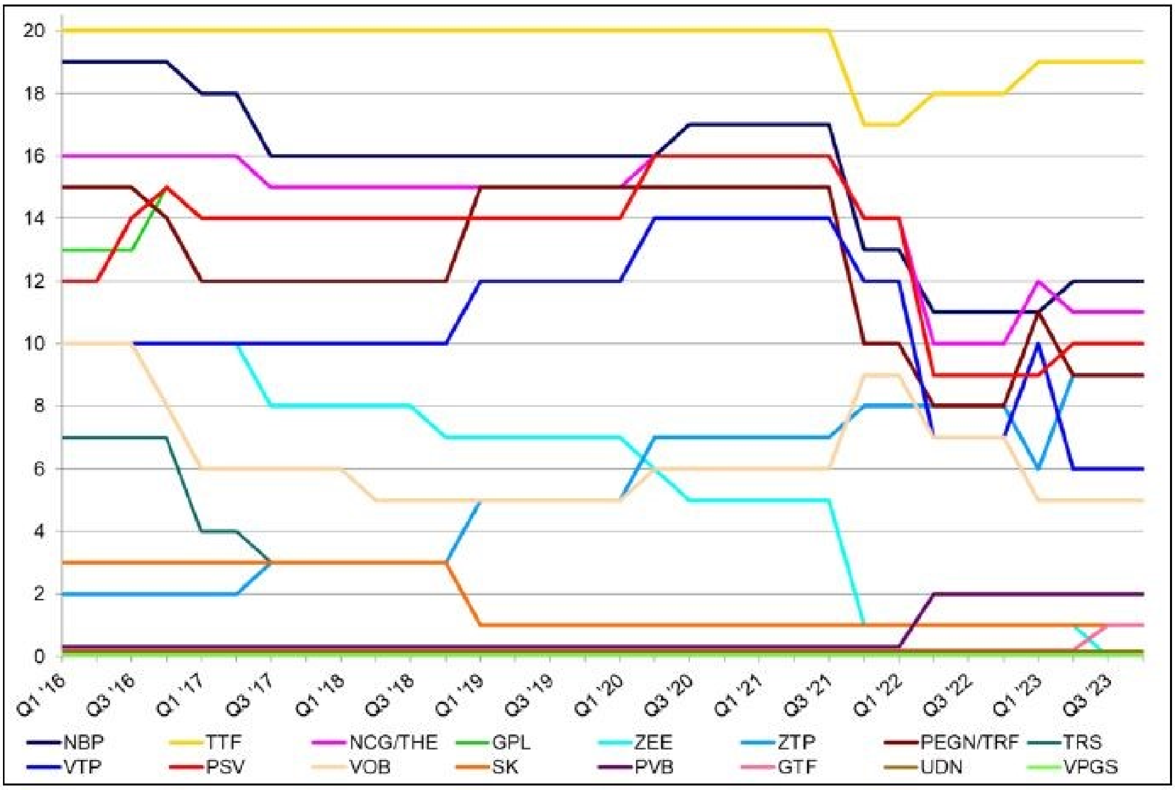


Figure 5 highlights that after a sharp decline in scores across most hubs in 2021, followed by generally low results in 2022, the majority of hubs saw a modest recovery in 2023, gaining just 1 point. However, 7 hubs did not recover: 3 experienced further declines, and 4 remained unchanged. Although this metric does not fully capture market depth, the data clearly show that the Dutch TTF hub leads significantly, boasting an almost perfect score of 19 out of 20, reflecting tight bid-offer spreads in all but one contract.

Key Element 5: Churn rates

Key Element 5, the churn rate of traded gas hubs, serves as a pivotal measure of market liquidity and activity. This metric encapsulates the frequency and volume of trades, reflecting the overall dynamism of a hub. A higher churn rate indicates a more vibrant and liquid market, where multiple participants are actively trading a variety of products in substantial quantities. Traders often use the churn rate as a benchmark for market engagement; a churn rate below 10 is generally considered insufficient for some traders, while financial participants typically look for markets with a churn rate above 12 to ensure robust liquidity. According to the author's criteria, a hub is deemed 'mature' if its churn rate reaches or exceeds 10.

The churn rate is assessed using two methodologies: net churn rate and gross churn rate. In the nascent stages of a hub's development, net churn, which focuses on trading within the hub's own market area, may suffice. However, as a hub matures and engages in more extensive risk management and hedging, gross churn becomes more relevant. Gross churn reflects the hub’s capacity to act as a pricing benchmark beyond its own market area, capturing both the trading of physical gas and financial transactions intended for various regional markets.

Table 5 outlines the net and gross churn rates for the top 10 gas hubs analyzed in this study. The methodology applied in this table categorizes hubs as follows: green for scores of 10 or higher, amber for scores below 10, red for scores under 5, and brown for those below 1. The 2023 results highlight that the Dutch TTF remains the sole European benchmark hub, well ahead of its peers, and is the only one classified as ‘mature.’ The British NBP, while no longer considered a mature hub, still falls within the ‘active’ category based on gross churn. In 2023, the Austrian VTP came closest to meeting the threshold of five churns for ‘active’ hubs, with a net churn rate of 9.3. Meanwhile, Germany’s THE and France’s TRF hubs showed improvement but remain in the 'poor' category for both gross and net churn. Italy's PSV hub improved to a churn rate of 1.9, returning to its 2020 level, while the Czech VOB saw a significant rise in gross churn, driven more by a decline in 'transit' gas than an increase in traded volumes. The remaining hubs reported churn rates below 1, marking them as 'illiquid.'

Globally, since 2019, the author has calculated churn rates for key benchmark hubs. When considering physical consumption from surrounding countries, the TTF achieved an impressive and mature churn rate of 36.8 times. The author firmly believes that the TTF is a reliable benchmark, offering accurate price signals for gas in the north-western European grids, widely used by shippers across Europe to price contracts and hedge portfolio risks. (Heather P, 2024)

Table 5: Churn Rates in 2023 (Heather, 2024)

2023	TRADED GAS HUBS CHURN RATES					
	Net Churn* basis			Gross Churn** basis		
HUB	2021	2022	2023	2021	2022	2023
TTF	136.7	142.1	223.8	67.5	63.0	100.9
NBP	8.0	8.2	8.9	7.3	6.1	7.1
VTP	9.3	8.0	9.3	1.9	2.4	4.2
THE	3.2	3.9	4.6	1.8	2.4	3.6
TRF	1.9	3.4	4.7	1.6	2.4	3.2
PSV	1.4	1.3	2.0	1.4	1.2	1.9
VOB	0.9	1.1	1.3	0.2	0.3	1.1
ZEE+ZTP^	1.6	3.6	3.1	0.7	0.9	0.9
PVB	0.5	0.7	1.0	0.4	0.6	0.8

* Total traded volume / Consumption in hub area.
** Total traded volume / Demand in hub area (= Total Physical Throughput = Consumption + Exports).
^ Physical volumes are for Belgium as a whole; 2023 figure is for ZTP.

A summary of the traded gas hubs in 2023

Table 6 highlights the 5 Key Elements for the 9 main traded gas hubs in Europe in 2023. The combination of these elements and their respective scores determine each hub's overall ranking, which is visually represented through color coding in the figure 3. The methodologies applied in this table are as follows: Green indicates a score of 18 or higher, amber for scores of 16 or higher, red for scores below 16, and brown for scores under 5. In terms of hub rankings, green represents 'mature' hubs with scores between 12 and 15, orange signifies 'active' hubs scoring between 8 and 11, amber denotes 'poor' hubs with scores between 4 and 7, and Red marks 'inactive' hubs with scores ranging from 1 to 3.

The Dutch TTF stands as the only 'tier one' mature hub, achieving a perfect score of 15/15. Each of the 5 Key Elements is marked in green, with TTF outperforming all other hubs in every category. The British NBP, which transitioned from a 'mature' to an 'active' 'tier two' hub in 2021, has maintained that status due to a drop in its Tradability Index score and a reduced churn rate, which declined from 11.2 in 2020 to 7.1 in 2023. Three other hubs are classified as 'active', each scoring 8/15. The German THE and French TRF both dropped one point from their 9/15 scores in 2022, while the Italian PSV improved by one point, moving up from the 'poor' category in 2022. The Austrian VTP, which scored 8/15 in 2022, fell to 7/15 in 2023. The three remaining 'poor' hubs are Belgium's ZTP, which dropped one point to 4/15, as well as Spain's PVB and the Czech VOB, both of which remained at 4/15 from 2022.

An analysis of the 5 Key Elements reveals that the Dutch TTF is clearly the dominant gas hub in Europe, serving more market participants than any other. It leads in traded product variety, holds significantly higher traded volumes than all other hubs combined, and accounts for 81.5% of European gas trading. Additionally, TTF represents 56% of OTC trading and 87% of exchange trading. It also boasts the highest Tradability Index, missing only one point on a 'balance of month' contract, and has the highest churn rate by far.

Table 6: Summary of the 5 Key Elements (Heather,2024)

2023	5 KEY ELEMENTS					
HUB	Active Market Participants*	Traded Products**	Traded Volumes	Tradability Index (Q4)	Churn Rate***	Score /15****
TTF	200	49	64980	19	100.9	15
NBP	135	40	6185	12	7.1	11
THE	90	35	3710	11	3.6	8
TRF	75	26	1675	9	3.2	8
PSV	58	25	1275	10	1.9	8
VTP	68	21	690	6	4.2	7
ZTP	55	14	470	9	0.9	5
PVB	46	15	335	1	0.8	4
VOB	44	12	90	5	1.1	4

* Hub Score in the OTC Active Traders table.
** Score /56 derived from the OTC and Exchange product categories in the Traded Products Table.
*** Gross churn basis.
**** Score based on each of the Key Elements scoring zero for Brown; 1 point for Red; 2 points for Amber; 3 points for Green.

2.2.2 The 3 Main Indicators

The Main Indicators are crucial for advancing towards fully liberalized gas markets throughout the EU. They encompass:

- **Political Will**: Essential for initiating and driving the market liberalization process.
- **Cultural Attitude**: Necessary for fostering a thriving trading environment.
- **Commercial Acceptance**: Vital for implementing and adapting to market changes effectively.

While these indicators are inherently subjective, they are fundamental to the growth of a traded gas market. However, they do not guarantee market success, as evidenced by comparing Table 8's results with the metrics outlined in Table 6.

The EFET Gas Hub Development Study provides a robust framework for assessing these Main Indicators across different countries. This study evaluates:

- **Five Regulatory Conditions**: Examining the support provided by regulatory frameworks for market development.
- **Five TSO Conditions**: Assessing the effectiveness and efficiency of Transmission System Operators.
- **Six Market Factors**: Analyzing various elements that impact market operation and competition.

Table 7 offers a detailed view of these factors, reflecting their role in the effectiveness of gas markets across Europe. The independent EFET study, using criteria distinct from the 5 Key Elements, aligns closely in its assessment of the growth stages of European hubs. In 2019, EFET stopped evaluating the older, well-established hubs in Northwestern Europe and shifted its focus to the ‘emerging’ hubs, adding Croatia and Slovenia to the assessment, and incorporating the Irish IBP in 2020. No study was released that year, but in 2021, EFET revised its hub scoring criteria to better reflect the specific challenges of these newer markets. The evaluation removed the volume of trades in long-term products as a criterion, replacing it with a measure of market interference. Lower scores were assigned when regulatory authorities imposed conditions that created barriers to market entry or trading.

While EFET did not publish a report in 2022, the 2023 study expanded its coverage to include Moldova and Serbia, bringing the total number of assessed emerging hubs to 18. The ranking methodology is as follows: hubs scoring 18 or higher are categorized as ‘mature’ (green), scores below 18 fall into the ‘active’ (orange) category, scores under 15 are labelled ‘poor’ (amber), and those below 9 are deemed ‘inactive’ (red).

This system was originally designed when the study focused on well-established hubs. However, in the current year, with the focus solely on ‘emerging’ hubs, all the assessed countries fall within the lower two categories. The results, presented in Table 8, show a general trend of steady improvement across these markets. Between 2021 and 2023, eight hubs saw further improvements, six remained stable, and two, Turkey’s UDN and Bulgaria’s VTT, experienced declines.

According to the EFET press release accompanying the 2023 study, Greece and Ireland showed the most significant improvements. Greece benefited from better balancing and a more established exchange, while Ireland saw enhanced market-based balancing, and its index gained increased relevance. The Baltic states also made gains, especially Lithuania, due to improved transparency and a gas release program. Slovenia slightly surpassed Croatia in market design, although Croatia remains more actively traded. Poland’s score improved slightly, though trading remains difficult. Meanwhile, Ukraine managed to maintain its trading activity despite the challenges it faces, and Hungary stayed at the top of the table, though still below the threshold for a ‘mature’ hub. On the other hand, Slovakia and Romania showed little progress.

In contrast, Turkey’s score dropped due to worsening transparency and trading conditions, while Bulgaria’s decline was attributed to less market-based balancing, increased trading obligations, and market interventions that hinder competition and liquidity. Moldova and Serbia, newly added to the study, were found to have only basic hub designs, reflecting partial implementation of EU regulations rather than the comprehensive reforms needed to foster wholesale trading.

Table 7: The 3 Main Indicators scoring process (EFET, 2023)

Criteria	Responsible party	Heading 2023	Guidelines for assessment 2023	Max Score 2023
1.a	NRA and/or Ministry		0.5 if relevant market access documents and/or legislation	1,5

1.b	TSO/Market Area Manager/Market Operator	Transparency and consultation	transparent and easily accessible on the internet; 1 if there is also regular consultation/stakeholder dialogue on relevant market issues; 1.5 if all of the above undertaken in English 0.5 if regularly updated network codes and market arrangements transparent and easily accessible on the internet; 1 if there is also regular consultation/shipper metings; 1.5 if all of the above undertaken in English	1,5
2	TSO	Entry-exit system established	0 if no transmission Entry Exit and/or VTP; 0.5 if transmission Entry Exit but with conditional capacity only available at certain points, restricting access to VTP or Entry Exist co-exsting with point to point within a country; 1 if transmission Entry Exit with full access to VTP	1
3	TSO	Title Transfer	1 if gas can be traded without having to enter into a transportation contract for physical delivery (nomination of flows) by way of trade notifications transferring gas between balancing groups at the VTP; 0.5 if gas can be traded at the VTP but a transportation contract is required; 0 otherwise. NB Balancing accounts (established through contracts or the network code) may still be legitimately required of pure traders	1
4	TSO	Cashout rules (long short positions imbalances set to zero at the end of the day with payment/receipt of imbalance	0 if non-daily or non-financial cashout; 0.5 if rolling imbalances with linepack flexibility service or daily cash out with tolerances; 1 otherwise	1

		charge in local currency/MWh)		
5	TSO/Market Area Manager/Market Operator	TSO system balancing	1 if TSO relies exclusively on short term standardised products (Article 7 of BAL NC); 0.5 if short term standardised products are used in conjunction with balancing services (Article 8 of BAL NC) such as load flow commitments or TSO storage; 0 if balancing services are used exclusively.NB arrangements intended to apply only in emergency situations, such as long-term load shedding options (in Germany) and operating margins (in UK) do not apply	1
6.a	NRA/Ministry	Licensing and reporting obligations	0 if licensing and reporting obligations are considered to be overly bureaucratic and a barrier to market entry; 0.5 if either lisensing or reporting obligations are considered overly bureaucratic and are barrier; 1 otherwise	1
6.b		Market inteference	0 if damaging instances of market inteference are prevalent; 0.5 if irregular market intervention has occurred with justification, 1 if market intervention is not perceived to be an issue	1
7	NRA	Resolve market structural and concentration issues (defined role for historical player if flexibility/liquidity is scarce)	0 if market hampered by structural or market concentration issue; 0.5 if gas/capacity release programs have been applied; 1 if mandatoty market maker obligations or if no perceived structural or market concentration issues	1

8	NRA, TSO or Market Operator	NRA fees or Hub fees (not fees relating to participating on a exchange or trading platform)	0 if discretionary or non-transparent; 0.5 if regulated or transparent and shown to be cost reflective; 1 if no fees or fees part of regulated TSO costs	1
9	Market	Establish a reference price at the hub for contract settlement in the event of default	1 if price always available based on Article 22 of BAL NC; 0.5 if proxy price based on neighboring hub; 0 if adminstered	1
10	Market	Standardised contract	1 if standard trading agreement (EFET or equivalent) widely used by all market participants, 0 otherwise	1
11	Market	Price Reporting Agencies producing daily prices at the hub	1 if more than one, 0.5 if only one or none daily publication; 0 if none	1
12	Market	Voluntary market makers operating at the hub	0 if none and liquidity is low and/or bid/offer spreads are wide; 0.5 if 1 or 2; 1 if several or not necessary because of high liquidity and narrow bid/offer spreads	1
13	Market	Brokers	0 in no brokers; 0.5 if voice brokers or 1 or 2 screen brokers; 1 if more than 2 screen brokers. Plus additionl 1.5 if screen brokers linked to Trayport	1,5
14	NRA	Establishment of exchange	0 in no exchange; 0.5 if non-cleared exchange; 1 if cleared exchange. Plus additional 1.5 if cleared exchange is linked to Trayport	1,5
15	Market	Hub price becomes reliable and used as benchmark	0 if hub price not transparent or trusted; 0.5 if hub price used as the basis for settling short term trades; 1 if hub price used in at long term contracts (e.g. storage and supply) of at least a year	1

16.	Market	Hub spot (shorter than monthly products) liquidity	0 if total annual traded spot volume (OTC + exchange) is <50 TWh 0.5 if volume >50 TWh but < 150 TWh; 1 if >150 TWh	1
Total				20

Table 8: EFET Hub scores categorised as mature, active, poor and inactive; 2016–2023 (Heather, 2024)

HUB	Score 2016	Score 2017	Score 2018	Score 2019	Score 2020	Score 2021	Score 2023
MGP	9	12½	11½	12½	13½	14	14
IBP	n/a	n/a	n/a	n/a	9½	12	14
HTP	5½	6½	8½	10	10½	12	13½
Lithuania	n/a	n/a	n/a	n/a	8½	11	13
Finland	n/a	n/a	n/a	n/a	9	11½	12½
Estonia	n/a	n/a	n/a	n/a	8½	11½	12½
Latvia	n/a	n/a	n/a	n/a	8	11½	12½
SVOB	8	8½	9½	10	10½	12	12
Ukraine	n/a	3½	3½	7	9	11	11
VPGS	9½	10	9½	9½	10	10½	11
Slovenia	n/a	n/a	n/a	6	6½	9½	10
Croatia	n/a	n/a	n/a	7½	8	9½	9½
Portugal	n/a	n/a	4½	5½	5½	9½	9½
UDN	4	5½	6	9½	10½	11½	9
Romania	2	3	3	4½	6½	8½	8½
Bulgaria	1½	1	4½	5	7½	9	7½
Moldova	n/a	n/a	n/a	n/a	n/a	n/a	3½
Serbia	n/a	n/a	n/a	n/a	n/a	n/a	3½

2.3 Review of the 5 Key Elements and the importance of LNG

The surge in LNG imports has significantly impacted the dynamics of European gas hubs in recent years, with a notable increase in traded volumes at hubs receiving higher LNG volumes. This trend is highlighted by the exceptional performance of Belgium (ZTP), France (TRF), and Spain (PVB), which have shown considerable growth across nearly all five Key Elements of market assessment.

In the period from 2021 to 2022, the leading European countries in terms of LNG sendout volume growth were Belgium, France, the Netherlands, the United Kingdom, and Spain. Belgium saw an impressive 175% increase, France followed with a 104% rise, the Netherlands experienced a 102% increase, the UK grew by 70%, and Spain saw a 44% increase.

The influx of LNG into these hubs has had a dual effect: it not only increased the volumes traded but also amplified the need for gas trading activities within these markets. This phenomenon is driven by the fact that both LNG suppliers and purchasers typically sell the LNG into the hub and buy the regasified gas from it, thereby boosting trading volumes. This effect is observed regardless of the specific contractual pricing mechanisms employed. For instance, LNG contracts might reference the TTF marker price, necessitating additional risk management trading at the TTF hub.

The ongoing shift toward diversifying gas supply sources and reducing dependence on Russian gas has driven significant infrastructure growth, notably with the addition of new LNG terminals and Floating Storage Regasification Units (FSRUs) in countries like the Netherlands and Germany. These advancements are expected to further boost trading activity at the Dutch TTF and German THE hubs in 2024, following similar trends seen at hubs in Belgium, France, and Spain throughout 2023.

After a thorough examination of the five Key Elements and additional analyses, it's evident that the Dutch TTF stands out as the premier European gas trading hub. It is utilized by a significantly larger number of market participants compared to any other hub. TTF boasts an exceptionally high score for traded products and its total traded volumes far surpass those of all other hubs combined. The TTF handles 81.5% of all European gas trading, 56% of all OTC trading, and 87% of all exchange trading. Additionally, TTF leads with the highest Tradability Index score, missing just one point on a single 'balance of month' contract, and exhibits the highest churn rate among all hubs.

Chapter 3: The role of hubs in natural gas pricing

3.1 Natural gas wholesale price formation

Natural gas wholesale prices are generally determined through either market-based pricing mechanisms or price regulation. According to the International Gas Union (IGU), three key market-based pricing methods are prevalent:

1. **Oil Price Escalation (Oil Indexation):** This mechanism links natural gas prices to the prices of competing fuels like crude oil, gas oil, or fuel oil. It typically involves a base price that can be adjusted through an escalation clause based on the price movements of these commodities.
2. **Gas-on-Gas Competition (Spot Hub Pricing):** In this approach, natural gas prices are indexed to spot market prices, where they are influenced by supply and demand dynamics. Gas is traded both physically and electronically at designated trading hubs.
3. **Netback from Final Product:** Here, the price received by the gas supplier is determined by the final product's market price, which the buyer produces, such as ammonia.

In a market-based pricing environment, several factors impact natural gas prices, including supply and demand fluctuations, exploration and production activities, storage levels, weather conditions, and the pricing and availability of alternative fuels. Additionally, the market outlook and expectations of key players can influence prices. Sometimes, gas prices are indexed to other commodities like oil, meaning that price changes in the oil market can directly affect natural gas prices. The concept of substitution underpins this oil indexation method (Hulshof, Maat, & Mulder, 2016).

In contrast, when the wholesale price of natural gas is set by the government, it aligns with specific policy objectives, a practice commonly referred to as price regulation. According to the IGU, such price regulation mechanisms are predominantly utilized in regions like the former Soviet Union, the Middle East, China, Malaysia, and Indonesia. In Russia, for instance, the pricing system is a hybrid, with the regulated sector dominated by state-owned Gazprom and the non-regulated sector led by independent producers.

In North America, natural gas prices are determined by a competitive market structure. The concept of gas-on-gas competition was pioneered in the United States, where prices are established through active trading in spot and futures markets by a large number of informed buyers and sellers.

For over a decade, Europe has seen the coexistence of gas pricing systems based on both spot markets and oil-indexed formulas. Oil indexation, which was first introduced in Europe in the 1960s, spread to Asia and remains the dominant model there. However, in Europe, oil indexation has been gradually losing ground to hub-based pricing. The shift towards gas-on-gas competition in Europe has been driven by the EU's competitive market strategies and the increasing preference of market participants for hub-based pricing. Since 2005, the European gas market has been steadily transitioning away from oil indexation towards a more competitive pricing environment based on gas-on-gas competition (Melling, 2010).

Gas-On-Gas competition VS Oil-Indexation

Oil-indexed prices have historically been associated with long-term contracts, whereas hub prices have been associated with spot or short-term contracts. Long-term contracts indexed to oil prevailed in the gas sector because they were thought to provide investment security for the producer as well as supply security for the consumer. Oil-linked prices were also thought to be more predictable than gas-on-gas competition-set prices. However, they are now under pressure from several factors, including the fallout from the 2008 financial crisis, the full liberalization of British energy markets, the deregulation of European electricity prices, and the arrival of shale gas. It is worth noting that in gas-indexed markets such as the United States and the United Kingdom, the oil indexed price has a high long-run correlation with the gas indexed price.

There has been much discussion about basing gas pricing on oil product prices. With a significant degree of spot gas pricing indexation in long-term contracts, the transition away from oil product price linkage in contracts has already begun. Change is desired by major European wholesalers. A gas price mechanism that reflects the market value of the product, on the other hand, should be viewed as a natural evolution for commodity pricing. Indeed, long-term contracts with prices linked to the gas market would ensure a price level reflecting the product's supply and demand balance, as well as supply security. Gas-on-gas competition is widely regarded as providing the "right" price of gas. Another advantage of market pricing is that it allows for separate financial risk management by distinguishing between the "financial" and the "physical." Pricing in the market is also more transparent and open. The big question is whether traded gas markets will become the primary driver of gas prices in Europe (El-Katiri & Honore, 2012).

Traded markets are rising, whereas oil-indexed markets are falling. Nonetheless, despite the upward trend in gas spot indexation, oil indexation will most likely continue to be the main pillar for pricing gas and will coexist with traded markets in continental Europe for many years to come. Most European pipeline import contracts, which last 20-30 years, are still heavily oil indexed. As a result, oil-indexed pipeline contracts are the primary source of supply influencing marginal pricing at hubs. Clearly, major gas producers – particularly Gazprom (Russia) and Statoil (Norway) – share a common interest in controlling physical flow into Europe to keep hub prices broadly in line with oil-indexed pipeline supply.

The development of "gas-on-gas competition," according to IGU, will most likely benefit from the development of a global LNG market. Each country's natural gas demand will be met by domestic production, pipeline imports, and LNG imports. Increased shale gas production in North America, as well as significant shifts in global LNG supply patterns, demonstrate the strong interdependence of supply, demand, and price across continents. LNG is the fastest-growing component of the global natural gas market, and European LNG demand is expected to rise as a result of the decline in North Sea production and the overall increase in natural gas demand due to economic growth and the environmental benefits associated with natural gas. The high costs of LNG development will necessitate strict long-term agreements. Nonetheless, as project costs rise and buyers become more price sensitive, LNG pricing becomes more difficult. On the other hand, oil is becoming scarcer and more expensive, while natural gas is becoming more abundant. In this context, strict oil indexation is becoming less appealing to buyers (Heather P, 2024).

3.2 Spot hub pricing VS Long-term contracts

Long-term contracts in the natural gas industry establish a bilateral monopoly between sellers and buyers, typically lasting 20 to 30 years, though recent contracts often span 8 to 10 years. These contracts outline specific obligations for both parties, with risk-sharing mechanisms in place: buyers usually assume the volume risk, while sellers handle the price risk. Such contracts are crucial for companies making substantial investments in gas extraction and infrastructure, providing them with a secure demand and a steady revenue stream. Simultaneously, these contracts offer wholesalers supply security and support long-term energy planning.

During contract negotiations, gas producers prioritize agreements that ensure returns on their infrastructure investments, while buyers focus on securing favorable prices to enhance their competitive edge against alternative fuels. Oil indexation has been a common strategy to shield buyers from price volatility in competing fuels. However, due to historically high oil prices compared to lower natural gas prices, this mechanism has often benefited producers more. Consequently, producers have been reluctant to transition to hub-based pricing and remain hesitant to move away from traditional long-term contracts, often questioning a hub's ability to provide stable natural gas prices.

Historically, long-term gas contracts featured 20-year terms, take-or-pay (TOP) clauses, and quarterly price adjustments linked to the prices of competing fuels, typically oil. A TOP clause obligates the buyer to make a predetermined payment, securing a specified quantity of gas. However, as market conditions evolved, the minimum purchase commitments in these contracts became increasingly burdensome, with buyers sometimes paying significantly higher prices for natural gas than their competitors.

In contrast, spot market trading allows sellers and buyers to trade standardized natural gas products for various delivery dates and locations without the need for a specific ongoing relationship. Hub trading has become a valuable tool for balancing long-term contract volumes within a portfolio, particularly as delivery dates approach. These hubs now offer a practical alternative for both buyers and sellers to meet their obligations.

The success of a natural gas hub depends on its liquidity and transparency. As market liquidity and integration improve, hub prices are expected to better reflect the true demand and supply dynamics within the EU, making them less vulnerable to price manipulation. Key metrics for assessing a hub's efficiency include liquidity indicators such as the churn ratio (which reflects the frequency of retrading), the number of active trading parties, and the liquidity depth of the futures curve. Trade concentration, measured by the distribution of trade volumes among individual participants, is another important factor. The spot market has been expanding steadily in terms of both volume and churn ratio, with new hubs emerging across Continental Europe, driving increased competition and trade volumes.

The gas-on-gas competition pricing model requires the establishment of hubs operating within a competitive and transparent regulatory framework. Spot and futures transactions are essential to the development of hub-based pricing. The inclusion of non-gas entities, such as institutional investors, banks, and trading firms, in natural gas financial trading has further broadened the market. As a result, natural gas futures have become one of the largest physical commodity futures contracts globally, with volumes continuing to rise. Futures markets allow participants to hedge their physical positions by offering financial products tied to the underlying asset price, enabling them to mitigate risk and secure profits by locking in future prices. This hedging strategy is effective due to the strong correlation between futures prices and spot gas prices.

As the natural gas market continues to evolve, future pricing is likely to play an increasingly prominent role. However, this trend does not necessarily mean that market participants will abandon long-term contracts, which remain strategically important for securing long-term supply and demand. Despite changing market dynamics, the role of long-term contracts is set to evolve, particularly as they must now align with the regulations governing the integration of the EU's internal gas market. Enhanced market monitoring is expected, and contracts that do not comply with EU objectives may face rejection. The integration of the EU's gas markets is also anticipated to influence gas pricing mechanisms positively. The development of gas hubs aligns with the EU's energy strategy, with the European Commission, the Agency for the Cooperation of Energy Regulators (ACER), and National Regulatory Authorities (NRAs) working together to eliminate barriers to market integration and foster increased competition.

3.3 Gas price convergence, correlation and volatility

The EU's ambition for a Single Energy Market envisions a high degree of integration across Member States, with gas prices differing only by transaction or transportation costs. This level of integration implies that prices across various Market Areas should react to changes in supply and demand uniformly and simultaneously. When evaluating traded gas hubs, it is beneficial to assess factors such as gas price convergence, correlations across different markets, and the volatility of gas prices. These elements serve as valuable tools for gauging the progress and maturity of traded hubs.

Price Convergence

Effective price convergence between hubs requires that there be no significant barriers to physically transporting gas between them. While physical transport may not always occur, the ability to do so if needed is essential. When this capability is in place, markets will naturally 'arbitrage' any small price differences, bringing them back into alignment. While price convergence is a strong indicator of market integration, it can sometimes be misleading because it does not reveal whether a hub is actively trading, or its relative activity level compared to other hubs.

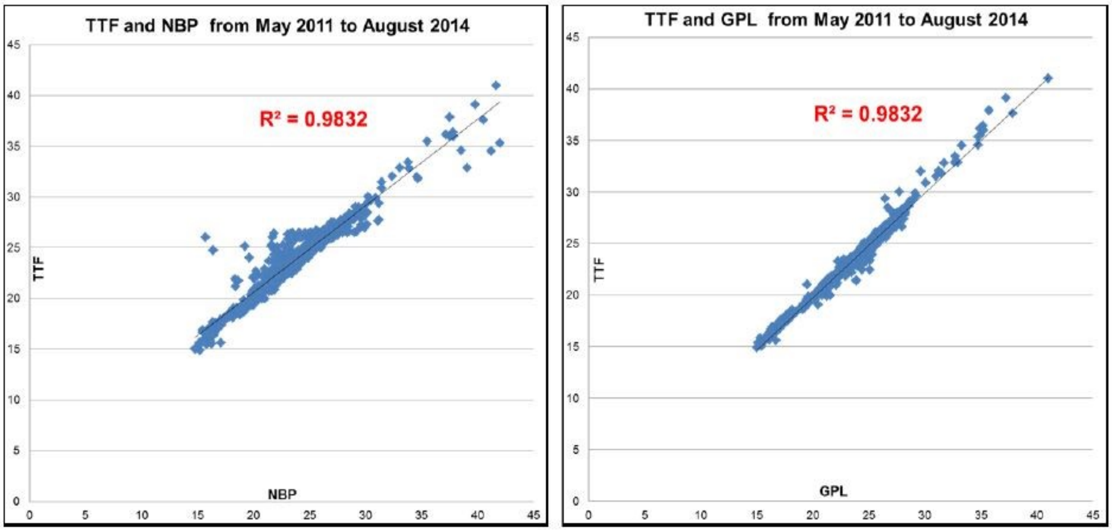
Price Correlation

Both price convergence and price correlation require careful analysis. Two markets might exhibit a high degree of correlation while still operating at different price levels, where the difference may be more or less than the cost of transportation. A strong price correlation does not necessarily indicate market integration and does not provide insight into the activity level of a hub. Price correlation means that prices move in tandem, both in direction and magnitude, at roughly the same time. However, it does not equate to identical prices, as seen in price convergence.

It's important to recognize that a close price correlation between two hubs might not influence the liquidity of either hub. For instance, in North West Europe, multiple hubs may display strong correlations, yet they often follow the pricing trends of highly liquid hubs like the UK's National Balancing Point (NBP) or the Dutch Title Transfer Facility (TTF). Consequently, even with sufficient physical transport capacity between hubs, a hub with low trading volume might still show strong correlation with a more liquid hub like TTF.

One approach to evaluating price correlation is through regression analysis, which examines the relationship between the prices at two hubs. This method models and analyzes numerical data – in this case, historical price data from May 2011 to August 2014 for specific hubs such as NBP, TTF, GPL, PEG Nord, and PEG Sud. The correlation between the prices at two hubs can be visualized using scatter plots, where the correlation coefficient (R^2) indicates the strength of the relationship. An R^2 value close to 1 suggests a strong correlation, while a score of zero indicates no correlation, and a range between 0.4 and 0.6 suggests a weak correlation.

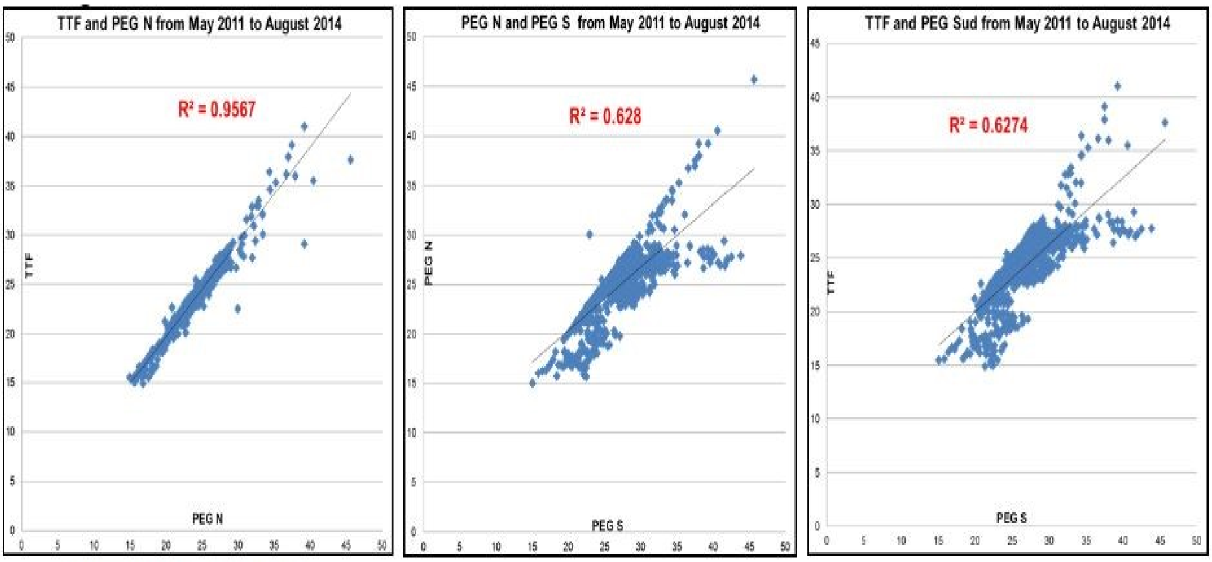
Figure 6: Correlation coefficients for TTF-NBP and TTF-GPL 2011-2014 (Heather, 2015)



The analysis presents several intriguing and significant observations: the two established gas hubs demonstrate an almost perfect correlation, as expected, with a correlation coefficient of 0.9832 (Figure 6, left). Interestingly, when comparing the Title Transfer Facility (TTF) and Gaspool, the same correlation coefficient of 0.9832 is observed (Figure 6, right). This high correlation persists despite the relatively lower traded volumes in the Gaspool market, indicating that its trades are closely aligned with TTF's pricing.

This strong correlation is particularly beneficial for risk management strategies, enabling market participants to hedge their portfolios effectively. Figure 7 illustrates the outcomes for the French market, highlighting an infrastructure constraint between the north and south. The correlation coefficient between TTF and PEG Nord (Figure 7, left) is quite strong at 0.9567, supporting the notion that many French market participants rely on TTF for portfolio risk management. However, the correlation between PEG Nord and PEG Sud (Figure 7, center) is significantly weaker, with a coefficient of just 0.628, reflecting the substantial volatility differences between these markets. Not surprisingly, the correlation between TTF and PEG Sud (Figure 7, right) is similarly low at 0.6274.

Figure 7: Correlation coefficients PEGN, PEGN-PEGS and TTF-PEGS 2011-2014 (Heather, 2015)



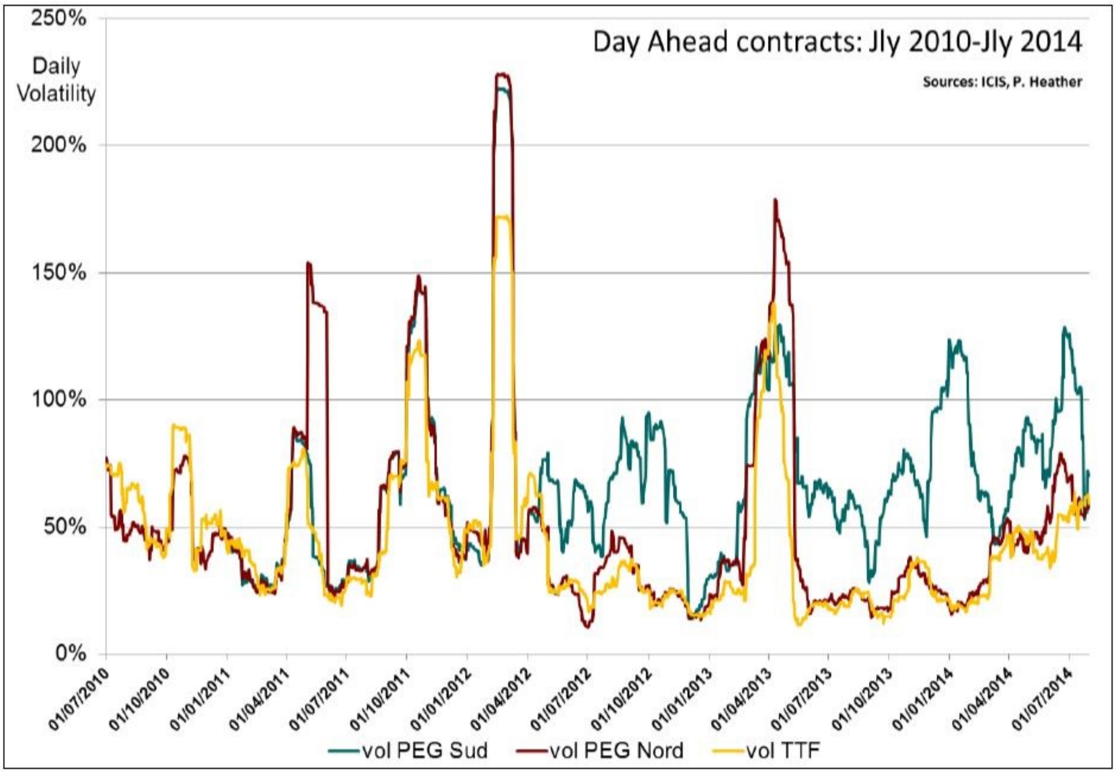
From a commercial perspective, high correlation between markets allows traders in one region to use a hub in another region to hedge their physical positions financially. However, when correlation is low, the risk increases, making it less likely that traders in southern France would use TTF to manage their risk.

Price Volatility

Price volatility and its relationship between hubs serve as another crucial metric in this context. Similar to price correlation, price volatility does not necessarily indicate market integration or reflect whether a hub is active, either in absolute terms or relative to other hubs. However, convergence in price volatility between hubs is important for two reasons: it is expected in an integrated European market, where neighboring hubs' prices should generally move in tandem regardless of whether the underlying market volatility is high or low. Additionally, it is a key indicator of market risks, and the challenges associated with hedging.

Significant differences in price volatility between hubs suggest that using one hub to hedge a physical position in another may not be prudent.

Figure 8: TTF/PEG Nord/PEG Sud hubs price volatility: 2010-2014 (Heather, 2015)



In addition to volatility, traders consider factors such as market access, data transparency, liquidity, and market depth, along with external influences that may vary between hubs. However, the key takeaway here is that while TTF can be effectively used to hedge physical positions in PEG Nord financially, it is not a reliable hedge for positions in PEG Sud or PEG TIGF. This is due to the financial risks posed by physical constraints between the Nord and Sud zones, which could impact traders' financial outcomes.

3.4 Gas exchanges and their role

Exchanges play a crucial role in the evolution of a traded commodity market by fulfilling five essential functions: price discovery, price transparency, supply and pricing flexibility, physical balancing, and financial risk management. Typically, exchanges introduce futures contracts for a specific commodity only after the underlying physical market has become well-jestablished. This approach is rooted in the nature of futures contracts, which are essentially derivatives of the physical market agreements. However, once the over-the-counter (OTC) market gains traction, many participants seek to engage in trading both financial products and the underlying physical contracts, primarily to manage financial risks within their portfolios.

Since exchanges operate as regulated marketplaces, they must maintain full transparency in all their operations, including details about the products being traded, the volumes involved, and the prices at which transactions occur. This transparency enables all participants in the gas market, as well as external observers, to access real-time or near real-time information on the current and future prices of gas. For instance, prices can be projected up to six years ahead on the ICE NBP and up to five years on ICE-Endex TTF. This level of visibility is crucial for market participants in making informed trading and investment decisions.

Exchanges, though primarily associated with financial transactions, sometimes facilitate the actual physical delivery of gas, even though only a small fraction of contracts typically culminate in physical delivery. This dual functionality allows exchanges to serve as a marketplace for buying and selling small quantities of physical gas. Additionally, exchanges can play a role in balancing a gas market area, as seen with the NBP On-the-day Commodity Market (OCM), which operates on the ICE-Endex platform. A key feature of exchanges is their ability to separate financial transactions from physical ones. Unlike traditional long-term contracts (LTCs) in Continental Europe, which often bundled physical delivery and pricing in one package, modern contracts typically fix the physical volume for the contract duration, while the gas pricing is determined at the time of delivery, referencing a market index, frequently an exchange-published index. This separation allows for effective price risk management through a secure, regulated market designed for hedging and trading.

There are six major exchanges that offer gas contracts on Europe's leading traded hubs. The International Petroleum Exchange (IPE), later rebranded as The ICE Exchange, pioneered gas futures contracts on the NBP in 1997. The NBP's balancing market, the OCM, initially traded on multiple platforms before moving to the APX, which eventually merged with Endex, forming what is now known as ICE-Endex. When examining exchange volumes, it's important to differentiate between Spot and Futures contracts. Spot contracts are generally used for final portfolio adjustments prior to physical delivery or for balancing at contract maturity. In contrast, Futures contracts are employed for medium-term portfolio optimization and long-term risk management. Moreover, most financial traders prefer dealing in Futures contracts rather than Spot contracts. By analyzing the volumes traded across different types of contracts, one can gain insights into trading patterns and behaviors at various hubs.

Chapter 4: SE Europe as a gas transit region

4.1 The rising SE European gas market

Southeast Europe serves as a crucial transport corridor linking Europe, Asia, and Africa, and plays an integral role in the Trans-European energy infrastructure. The European Union views the Southern Gas Corridor as a vital opportunity to diversify its energy sources, particularly by tapping into gas supplies from the Caspian region, including Azerbaijan, and potentially Turkmenistan, Kazakhstan, Iran, and Iraq in the future. Despite its strategic importance, Southeast Europe lacks a unified gas market. The region is characterized by a mix of markets, ranging from Romania, a large and mature market with a century-long history of gas consumption, to much smaller, less developed markets. A common feature across the region is the development of gas markets as isolated entities with a high reliance on imports, with the exception of Romania, and minimal access to Liquefied Natural Gas (LNG), apart from Greece.

The historical lack of interconnectivity in Southeast Europe underlies two significant strategic challenges: the slow progress in fulfilling the Energy Union's internal gas market objectives and the ongoing struggle to ensure a high level of supply security. Interconnectivity in this context has both a physical and regulatory dimension. The physical aspect involves the infrastructure, particularly pipelines, while the regulatory dimension encompasses the market rules, transportation protocols, and Network Codes established under the Third Energy Package. While substantial progress has been made in the regulatory domain, which is relatively low-cost, the physical infrastructure remains underdeveloped, necessitating significant capital expenditure.

Currently, six Southeast European countries—Greece, Croatia, Bulgaria, Romania, Turkey, and Serbia—are established natural gas consumers with markets primarily supplied by Russia, Iran, and Azerbaijan. Greece and Turkey, equipped with advanced LNG import and storage facilities, also source gas from Algeria, Nigeria, Qatar, and other LNG spot markets. Domestic production plays a significant role in meeting demand in Croatia and Romania, while in Bulgaria, Serbia, and Turkey, it accounts for a smaller share of consumption. One of the key factors in forecasting future gas demand in the region is the potential for gas to replace other energy sources in various sectors, including power generation, residential, commercial, and industrial applications. While relative pricing and competition from other fuels will be central to this transition, other influences such as environmental considerations and national energy policies will also shape demand growth.

The natural gas sector in Southeast Europe is widely expected to expand, driven by the growing demand for power generation, which is one of the fastest-growing segments within the broader Southeast European energy market. Although each individual gas market in the region is relatively small, adopting a regional approach offers a strong foundation for further development where all EU gas markets must be well-connected and resilient to supply disruptions. This goal is attainable for Southeast Europe, but it requires significant investments in basic infrastructure and continued market development. Table 9 illustrates the gas consumption needs of selected EU countries as projected by the European Commission.

Table 9: Gas consumption bcm in EU countries (European Commission, 2022)

Country	2020	2025	2030
Austria	7,5	7,3	7,1
Bulgaria	4,0	4,2	4,3
Greece	5,0	5,2	5,41
Croatia	3,7	3,8	3,9
Hungary	11,0	10,5	10,0
Italy	71,3	79,2	83,8
North Macedonia	0,1	0,1	0,13
Romania	13,0	13,5	13,5
Slovenia	1,2	1,2	1,3
Slovakia	7,0	7,2	7,3
Serbia	2,2	2,25	2,3
Turkey	60,0	65,0	70,0
Ukraine	35,8	36,0	36,5
Total gas consumption	**221,8**	**235,45**	**245,54**

4.2 Major natural gas projects in SE Europe

Because the SEE region is an important geostrategic energy corridor, there is a strong need for new energy projects to ensure energy security and energy transit to and across Europe. Regional energy cooperation has been viewed as a necessary part of the European integration process in the majority of SEE countries. The main goals of EU energy policy were incorporated into the long-term strategies of SEE countries at the start of the current decade. The emphasis has shifted to the modernization of existing energy facilities and the construction of new ones, as well as the improvement of energy efficiency and the increased use of renewable energy sources.

Trans Anatolian Pipeline (TANAP)

The Trans Anatolian Pipeline (TANAP) is a joint Azeri-Turkish project that brings Azeri gas to Turkey's European border, where it connects with the TAP pipeline. The TANAP project calls for the construction of a pipeline from Turkey's eastern border to its western border to transport gas from the Caspian Sea's Shah Deniz gas-condensate field. TANAP had a cost of around $10 billion. Turkey receives gas since 2018, and after the Trans-Adriatic Pipeline (TAP) completion, additional gas was delivered to Europe in early 2020.

The 1,850 km pipeline, which began construction in 2015, runs from the Georgian-Turkish border to the Turkish-Greek border. The South Caucasus Pipeline, which will transport gas from Azerbaijan to the Turkish border via Georgia, is being expanded and has a different ownership structure than TANAP. TANAP's initial transport capacity is 16 bcm of gas per year, with 6 bcm consumed by Turkish consumers and 10 bcm delivered to European countries via TAP. Following that, TANAP's total capacity is expected to increase to 31 bcm by 2026.

Overall, TANAP represents a significant milestone in the development of regional energy infrastructure, fostering cooperation and integration among Azerbaijan, Turkey, and European countries while advancing the goals of the Southern Gas Corridor.

Trans Adriatic Pipeline (TAP)

The Shah Deniz consortium chose the Trans Adriatic Pipeline (TAP) to transport gas from Turkey's western border to Europe. TAP connects Southeast Europe's existing and planned gas grids with Western Europe's gas systems via Greece, Albania, the Adriatic Sea, and Italy. As a result, the pipeline provides Europe with improved access to major gas reserves in the Caspian region. The pipeline, which is operational from 2020, is designed with an initial transport capacity of 10 bcm/year and a diameter of 48 inches. It is 682 km long onshore and 105 km long offshore. TAP construction costed around $5.3 billion. TAP's route can also facilitate gas supply to several Southeastern European countries, including Albania, Bulgaria, Bosnia and Herzegovina, Montenegro, and Croatia. TAP's arrival in Italy opened the door to additional Caspian gas transport to some of Europe's largest markets, including Germany, France, the United Kingdom, Switzerland, and Austria.

TAP plays a strategic role in diversifying Europe's energy sources and reducing dependency on Russian gas imports. By connecting the Caspian region with European markets, the pipeline enhances energy security and promotes market competition. It also fosters economic development and strengthens diplomatic ties between participating countries.

Ionian-Adriatic gas pipeline (IAP)

The Ionian-Adriatic gas pipeline (IAP) project, which is currently in the planning stages, would connect the gas transmission systems of Croatia, Montenegro, Bosnia and Herzegovina, and Albania to the TAP, forming an integral part of the Southern Gas Corridor and opening a supply route to the EU for Azeri gas from the Caspian Sea. It will be 511km long and have a transport capacity of 5 bcm/year, which could be increased if it is equipped with a reverse flow system.

The IAP pipeline is strategically significant for the region as it contributes to diversifying energy sources and routes, reducing dependence on a single supplier, and enhancing energy security. By connecting the Western Balkans with the European natural gas network, the pipeline promotes regional stability, economic growth, and integration with the broader European Union.

Turkish Stream

The construction of TurkStream began in 2017, and both lines became operational in January 2020. The pipeline is owned and operated by Gazprom, the Russian state-owned energy company and consists of two parallel lines, each with a capacity of 15.75 bcm of natural gas per year. TurkStream pipeline serves as a crucial route for the transportation of natural gas from Russia to Turkey and Southeastern Europe. The gas originates from Gazprom's gas transmission system in Russia and travels across the Black Sea to reach the Turkish coast. From there, one line delivers gas to Turkish consumers, while the other line continues through Turkey towards the Turkish-Greek border, where it connects with existing gas infrastructure for further distribution into Europe.

The construction of TurkStream has geopolitical significance, as it allows Russia to bypass traditional transit routes through Ukraine for gas exports to Europe. This diversification of transit routes reduces Russia's dependence on Ukrainian infrastructure and mitigates geopolitical risks associated with gas transit through Ukraine.

The Vertical Corridor

The Greek national grid could serve as the starting point for a gas system that will transport significant amounts of gas in a vertical axis (south to north) and in a constant flow to Bulgaria and Romania, and from there to several countries including Hungary, Serbia, Moldavia, and others. The above concept, known as the Vertical Corridor, is a supplement to the South Corridor and has been adopted by the governments of Greece, Bulgaria, and Romania, and will significantly contribute to gas interconnectivity in SE and Central Europe. The Vertical Corridor is emerging as a project to bridge the interconnection gap between SE Europe's isolated markets and to provide reverse-flow options for existing routes.

In contrast to the other south corridor projects, the Vertical Corridor concept will be a gas system that will connect existing national gas grids and other gas infrastructure to secure energy security and ensure liquidity. Such a gas system will be a vital link from south to north, fully aligned with European energy policy. The Vertical Corridor will initially transfer 3-5 bcm/year from the Greek national grid and could eventually transfer 8 bcm.

The East Med Pipeline (East Med)

The East Mediterranean (East Med) pipeline project is an offshore/onshore gas pipeline that will connect East Mediterranean gas resources directly to the European gas system. The pipeline will transport up to 15 bcm of gas from offshore gas reserves in the Levantine Basin (Cyprus and Israel) and potential reserves in Greece to the Greek gas system and the Italian gas system via the aforementioned Poseidon pipeline.

The East Med pipeline project comprises the following sections:

- about 150km offshore pipeline from the Levantine Basin to Cyprus
- about 650km offshore pipeline from Cyprus to Crete
- about 400km offshore pipeline from Crete to Peloponnese
- about 500km onshore pipeline on the Greek territory up to the connection with Poseidon pipeline in the Thesprotia region

At first glance, the most significant impediment to the East Med pipeline's construction is its technical viability. There are numerous practical challenges. On the way to Crete, for example, there is a stretch of about 10 km where the depth is quite deep, which could cause construction issues. The companies involved, however, are optimistic that technology will advance enough to allow the pipeline to be built. According to preliminary estimates, the project's construction costs could exceed €6 billion, and it is currently classified as a Project of Common Interest (PCI) by the EU.

The East Med Pipeline holds strategic significance for both the countries in the Eastern Mediterranean region and Europe. For the producing countries, such as Cyprus and Israel, the pipeline offers an opportunity to monetize their offshore gas reserves and strengthen their economies. For Europe, the pipeline provides diversification of energy sources and routes, reducing dependence on traditional suppliers and enhancing energy security.

Bulgaria-Romania-Hungary-Austria (BRUA) Corridor

The BRUA corridor connects Bulgaria, Romania, Hungary, and Austria via reverse-flow gas interconnectors. It is expected to have a transport capacity of 1.5 bcm/year towards Bulgaria and 4.4 bcm/year towards Hungary. An additional pipeline will be built to bring offshore gas onto the Romanian national grid and then onto BRUA. BRUA's advantage, despite its small capacity, is that it can deliver gas from both TAP and the Austrian Baumgarten gas hub while using existing gas infrastructure, leaving only additional compressor stations and pipeline segments to be built.

The development of the BRUA Corridor has progressed through various stages of planning, regulatory approvals, and construction. While some segments of the corridor are already operational, others are still under development or in the planning phase. As the corridor becomes fully operational, it is expected to play a crucial role in advancing energy connectivity, market integration, and regional cooperation in Southeastern Europe.

Eastring Pipeline

The Eastring Pipeline is planned to traverse several countries in Central and Eastern Europe, including Slovakia, Hungary, Romania, Bulgaria, and potentially other countries in the region. The exact route and specifications of the pipeline are subject to ongoing feasibility studies, regulatory approvals, and stakeholder consultations.

The primary objective of the Eastring Pipeline is to create a new gas transmission route that connects the Eastern and Central European gas markets with major gas sources, including the Caspian region, the Middle East, and potentially liquefied natural gas (LNG) terminals in Europe. The pipeline seeks to reduce dependency on single gas suppliers and transit routes, thereby enhancing energy security.

4.2.1 Gas interconnectors in SE Europe

Gas interconnectors in Southeast Europe are vital for enhancing the region’s energy security, market integration, and diversification of gas supply routes. In response to the need for increased resilience against gas disruptions, gas transmission system operators (TSOs) in Greece, Bulgaria, Romania, and Serbia are advancing plans to expand their gas infrastructure. This expansion includes the development of new gas interconnectors, which will provide the region with increased natural gas supplies from the Trans Adriatic Pipeline (TAP), the Revithoussa LNG terminal, and the Floating Storage Regasification Unit (FSRU) terminal in Alexandroupolis.

Interconnector Greece-Bulgaria (IGB)

The Interconnector Greece-Bulgaria (IGB) is a strategic bi-directional pipeline spanning approximately 182 kilometers. It links the Greek gas network in Komotini with the Bulgarian network in Stara Zagora. With an initial capacity of 3 bcm per year, the IGB can be expanded based on market demand and the capacities of adjacent gas transmission systems. The pipeline plays a crucial role in connecting with the Southern Gas Corridor and the Turkey-Greece Interconnector (ITG), thereby integrating with the Trans Adriatic Pipeline (TAP) and the Trans Anatolian Pipeline (TANAP). This interconnector enhances access to Caspian and Middle Eastern gas supplies, reducing Greece and Bulgaria's dependence on single suppliers and transit countries, thereby bolstering energy security.

Interconnector Turkey-Greece-Italy (ITGI)-Poseidon

The Interconnector Turkey-Greece-Italy (ITGI)-Poseidon project is a comprehensive initiative designed to link Turkey, Greece, and Italy through a combination of pipelines. The ITGI segment involves constructing a pipeline from Turkey to Greece, which strengthens Greece's energy security by diversifying its supply sources, including potential imports from the Caspian region and the Middle East. The Poseidon segment extends the pipeline from Greece to Italy via the Ionian Sea, further diversifying gas supply routes for both Greece and Italy. This project aims to diminish reliance on traditional routes through Ukraine and Russia, providing access to alternative gas sources and enhancing energy security for all participating countries.

Interconnector Greece-North Macedonia (IGNM)

The Interconnector Greece-North Macedonia (IGNM) is a proposed pipeline designed to link the gas transmission systems of Greece and North Macedonia. According to DESFA's Ten-Year Development Study, this interconnector will provide North Macedonia with additional gas supply sources, complementing its current reliance on the Trans Balkan Pipeline. Initiated through a Memorandum of Understanding between Greece's DESFA and North Macedonia's State Company for Energy Resources MER in October 2016, the IGNM aims to establish a bi-directional pipeline with an initial capacity of around 3 bcm/year. This infrastructure is essential for enhancing energy security, facilitating market integration, and fostering greater cooperation between Greece and North Macedonia.

Interconnector Bulgaria-Romania (IBR)

The Interconnector Bulgaria-Romania (IBR) is a planned pipeline intended to connect the gas networks of Bulgaria and Romania. This interconnector is designed to bolster energy security, enhance market integration, and allow the bidirectional flow of natural gas between the two nations. With an initial capacity projected at approximately 1.5 bcm/year, the IBR pipeline has the potential for future expansion based on demand and infrastructure developments.

Interconnector Turkey-Bulgaria (ITB)

The Interconnector Turkey-Bulgaria (ITB) is established to connect the gas networks of Turkey and Bulgaria, significantly contributing to regional energy security and market integration. This pipeline facilitates bidirectional natural gas flow between the two countries, with an initial capacity of about 3 bcm/year. The ITB pipeline is poised for future expansion to accommodate increasing demand and enhance gas trade between Turkey and Bulgaria.

Interconnector Bulgaria-Serbia (IBS)

The Interconnector Bulgaria-Serbia (IBS) links the gas networks of Bulgaria and Serbia, playing a critical role in improving energy security and market integration. This pipeline supports bidirectional gas movement with an initial capacity of around 1.8 bcm/year. Future expansion of the IBS is anticipated to meet rising demand and support increased gas trade between Bulgaria and Serbia.

These interconnectors collectively represent a major step forward in Southeast Europe's energy infrastructure, addressing supply diversification, enhancing regional energy security, and promoting greater market integration across the region.

4.2.2 The role of LNG in SE Europe

In the past five years, the LNG landscape in Southeast Europe and the East Mediterranean has seen substantial improvements. The introduction of new projects and the increasing attractiveness of LNG as a fuel are reshaping the region's energy dynamics. Enhanced supply security, competitive pricing, and greater availability are making LNG a compelling alternative for various industrial sectors. This transition is supported by the entry of new LNG suppliers such as the United States and Australia, which diversifies the supply base and mitigates reliance on traditional pipeline routes.

Greece

Revithoussa LNG Terminal

Located on Revithoussa Island near Athens, the Revithoussa LNG Terminal has been a cornerstone of Greece's LNG infrastructure since its inception in 1999. Managed by DESFA, Greece's transmission system operator, the terminal underwent a significant upgrade with the addition of a third storage tank in December 2018. This expansion increased its storage capacity to 225,000 cm and boosted its regasification capability by 40%, allowing it to process approximately 20.2 mcm of gas daily, or about 7 bcm annually. The terminal facilitates imports from a diverse range of global suppliers, including Qatar and the United States, thus enhancing Greece's energy security and reducing dependency on specific pipeline routes.

FSRU Alexandroupolis

The FSRU Alexandroupolis, located in northeastern Greece, represents a significant advancement in LNG infrastructure. Developed through a partnership between GasLog Ltd., Bulgartransgaz EAD, and Gastrade S.A., this floating storage and regasification unit (FSRU) handles LNG importation, storage, and regasification. With an annual regasification capacity of approximately 6.1 bcm, the FSRU Alexandroupolis is crucial for meeting the energy demands of Greece and neighboring countries. It helps diversify supply sources, including options from the United States, Qatar, and Australia, and supports regional infrastructure such as the Interconnector Greece-Bulgaria (IGB) and the Greece-North Macedonia Interconnector.

Dioriga Gas

The Dioriga Gas terminal, situated around 70 km from Athens in the Agioi Theodori area, will enhance Greece's LNG infrastructure further. Planned as a near-shore terminal, it will utilize a Floating Storage and Regasification Unit (FSRU) to import LNG. The terminal will have a storage capacity of up to 210,000 cm and will connect to the Greek National Natural Gas Transmission System (NNGTS). LNG will be transferred from carriers to the FSRU through ship-to-ship operations, where it will be regasified for distribution or exported as LNG via bunkering vessels and trucks.

Croatia

Krk LNG Terminal

The Krk LNG Terminal, located in Omialj on the island of Krk, Croatia, is a key player in strengthening Europe's energy market. This floating LNG terminal, backed by a €101.4 million EU grant and recognized as a Project of Common Interest (PCI), is strategically important for enhancing gas supply security in Central and Southeast Europe. The terminal features an FSRU vessel and an onshore component, providing a technical capacity of 2.9 bcm/year. It plays a crucial role in offering a reliable gas supply route and supporting Croatia's energy infrastructure.

Turkey

Since 2017, Turkey's LNG import capacity has more than doubled, surpassing 40 bcm annually. The country now operates two onshore terminals and two offshore FSRUs, which together meet over 90% of Turkey's gas demand. The terminals include those in Aliaga, Marmara Ereglisi, Etki Liman FSRU (Cakmakli), and Dortyol FSRU. Turkey's expanding LNG infrastructure supports its role as a critical energy hub, with the capacity to export LNG via pipelines like TAP (in its second phase) and through Turkey's interconnectors with Greece, as well as the TurkStream pipeline.

These advancements reflect the growing importance of LNG in Southeast Europe and the East Mediterranean, driven by the need for diversified and secure energy supplies. The region's LNG infrastructure is evolving to meet current and future demands, enhancing energy security, pricing flexibility, and supply reliability across Europe.

Figure 9: Existing and planned FSRUs in Greece and SE Europe (IENE, 2020)

4.2.3 Gas storage facilities in SE Europe

Underground gas storage plays a crucial role in ensuring a reliable and flexible supply of natural gas. Southeast Europe (SE Europe) has several gas storage facilities spread across Romania, Croatia, Serbia, Bulgaria, and Turkey, predominantly utilizing depleted gas fields. These facilities are essential for balancing seasonal demand fluctuations and enhancing regional energy security.

Romania

Romania is a major player in underground gas storage within SE Europe, boasting eight facilities across the country. Four of these are situated in the central regions, while the remaining are positioned in the south, close to Bucharest. Romania holds the second-largest gas storage capacity in the region, with a total working gas capacity of up to 3.1 bcm. This extensive network of storage sites is critical for maintaining stability and flexibility in Romania's energy supply.

Croatia

Croatia's sole underground gas storage facility is the Okoli Underground Gas Storage (UGS), located south of Zagreb. The Okoli facility has a working capacity of 553 mcm and plays a significant role in managing seasonal demand. It has a peak withdrawal rate of up to 5.8 mcm/day, with an injection rate of approximately 4 mcm/day. This facility is integral to Croatia's strategy for energy security and supply continuity.

Serbia

In Serbia, the Banatski Dvor underground gas storage facility, situated in the northern part of the country near the Romanian border, has a total storage capacity of 450 mcm. This facility, based on a depleted gas field, contributes to Serbia's energy reliability, especially during periods of high demand.

Bulgaria

Bulgaria operates a single underground gas storage site at Chiren, located north of Sofia. This facility, also utilizing a depleted gas field, has a total storage capacity of 550 mcm. Managed by Bulgartransgaz, Chiren is a key asset for Bulgaria's energy infrastructure, ensuring that the country can meet demand surges and maintain a stable supply.

Greece

Greece currently has a potential underground gas storage project at the depleted gas field in South Kavala. However, development of this project is anticipated to rely on public-private partnerships. If realized, this facility could significantly enhance Greece’s capacity to manage gas supply and demand more effectively.

Turkey

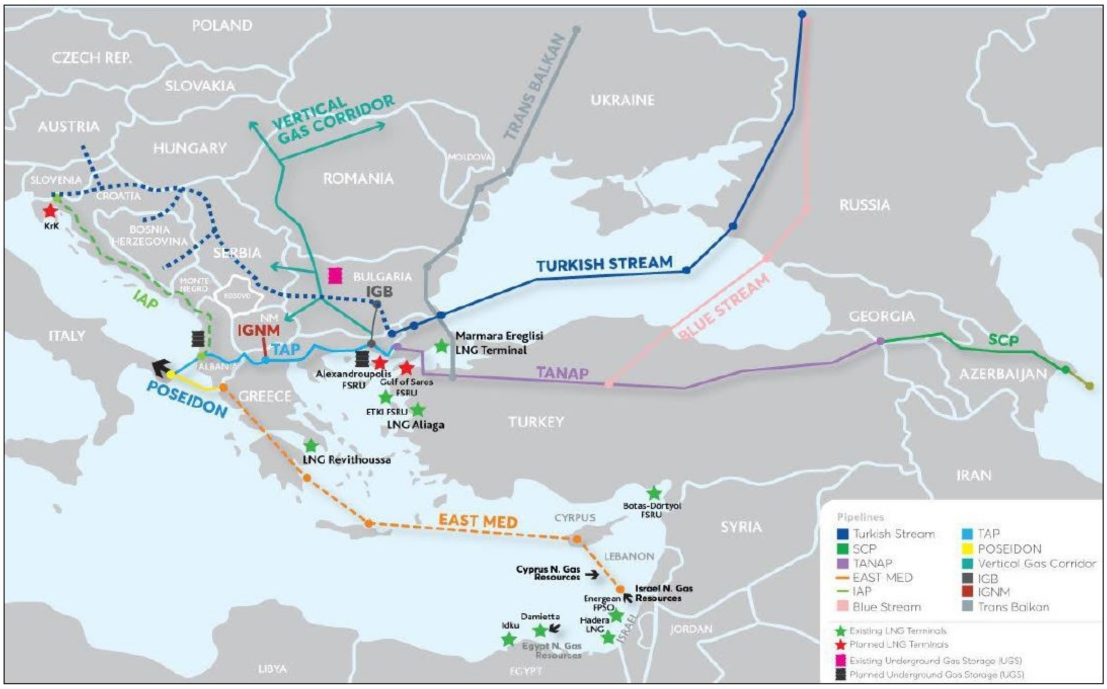
Turkey manages two underground gas storage facilities near Istanbul, utilizing the Kuzey Marmara and Deirmenköy depleted fields. Together, these facilities provide a total storage capacity of 2.84 bcm. They are crucial for Turkey's energy strategy, helping to stabilize supply and manage demand fluctuations.

Given Europe’s anticipated increase in gas imports and consumption, SE European countries are expected to expand their underground gas storage capacities. By 2030, Europe's dependence on imported gas is projected to rise to 70%, with gas consumption expected to reach 640 bcm. In response, storage capacity is anticipated to grow to 140 bcm, up from the 13.64 bcm estimated in 2015 for SE Europe.

While current storage capacities in SE Europe are deemed insufficient for long-term energy security, the region is turning to Liquefied Natural Gas (LNG) as a viable supplement. LNG can enhance supply security and flexibility, particularly during peak demand periods. Greece and Turkey currently use LNG to support their national gas systems, and new projects like the Krk LNG terminal in Croatia are set to bolster the region’s capacity further.

The development of additional underground storage facilities and LNG infrastructure will be crucial for SE Europe to meet future energy demands and ensure a stable and secure gas supply.

Figure 10: The Expanded South Corridor (Mezartasoglou, 2018)



Chapter 5: HTP: Progress and the road to maturity

Chapter 4 outlines significant progress in natural gas infrastructure across Southeastern Europe, highlighting ongoing projects that are steadily shaping the region's energy market. These developments are crucial for establishing a robust natural gas hub, enhancing energy security, and fostering market competition.

In recent years, Greece has intensified efforts to refine its wholesale gas market. The country's Transmission System Operator (TSO), DESFA, which is predominantly state-owned, manages both the national gas grid and two Floating Storage and Regasification Units (FSRUs). DESFA has introduced several key initiatives to bolster market efficiency, including a secondary gas trading platform and a Virtual Trading Point (VTP) for the resale of gas and transfer of transmission capacity rights.

In December 2013, Greece revised its Network Code, followed by the implementation of the European Commission Regulation 312/2014. This led to the launch of the Virtual Nominations Point (VNP) in April 2014, where wholesale customers, mainly large industrial users, began redirecting their supply contracts. By the first half of 2016, the VNP had evolved to serve as the Greek Balancing Point System, facilitating wholesale market operations and balancing activities. The VNP laid the groundwork for the development of a Virtual Trading Point (VTP), an essential step toward establishing a regional gas hub. Historically, successful hubs—whether physical or virtual—start as Balancing Points and evolve into Trading Points with more extensive forward curves as liquidity increases. With time, the VTP has the potential to become a significant regional gas hub.

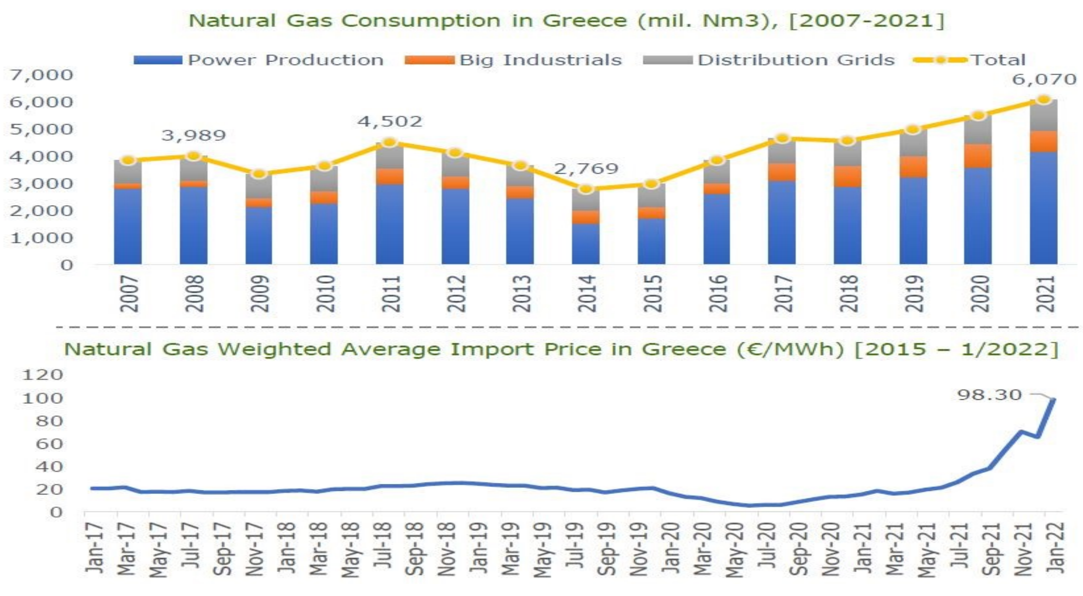
Greece has also taken substantial steps toward market liberalization and deregulation in its wholesale electricity sector. A notable advancement was the establishment of the Hellenic Energy Exchange (HEnEx) in 2018, which oversees the Energy Derivatives Market, Day-Ahead Market, and Intra-Day Market. A key development in this context was the launch of the Natural Gas Trading Platform by HEnEx on March 21, 2022. This platform operates in alignment with the EU BAL Network Code (Regulation (EU) 312/2014) and REMIT (Regulation (EU) 1227/2011), modernizing Greece's wholesale gas market framework.

The Natural Gas Trading Platform is an organized market where Transmission Users and DESFA can participate. It facilitates trading in short-term standardized products for balancing purposes. Transactions on the platform are conducted anonymously, though amounts are reported to DESFA automatically. HEnEx provides a range of pricing information based on transactions, including Closing Prices, the Next Day Gas Index (HGSIDA), the Intraday Gas Index (HGSIWD), and both Buy and Sell Marginal Prices. These initiatives reflect Greece's commitment to enhancing its gas market infrastructure, increasing competition, and supporting the development of a regional energy hub.

5.1 Greece's Natural Gas Landscape: Current Trends and Future Projections

Greece's natural gas consumption has seen a notable rise in recent years, reaching 6 bcm by 2021. A significant portion, approximately 69%, of this gas is allocated for electricity generation, driven by the gradual phase-out of lignite power plants. However, the landscape of natural gas prices and imports has been impacted by recent global events. In January 2022, natural gas import prices in Greece surged fivefold compared to the previous year, primarily due to disruptions in the supply chain exacerbated by the COVID-19 pandemic. This upward trend in costs is expected to persist, further influenced by the Russian gas crisis that began in February 2022. In response, Europe is aiming to collaboratively procure natural gas and build strategic reserves, targeting a 90% fill rate for storage facilities by the upcoming winter seasons.

Figure 11: Natural gas prices and demand (HAEE, 2022)



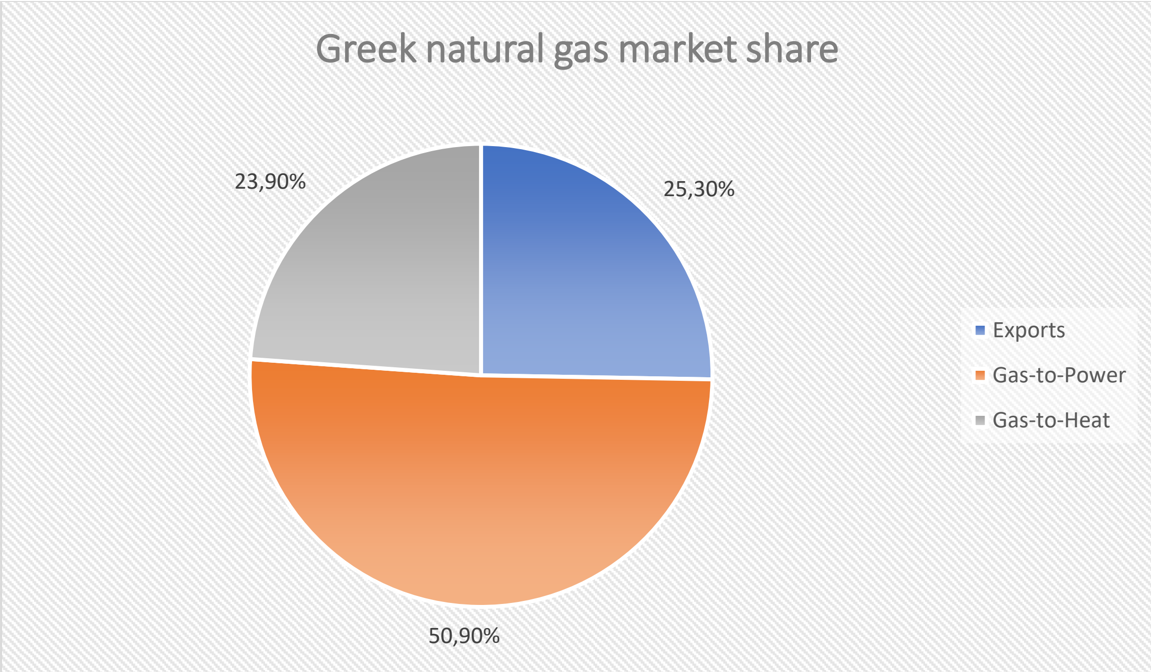
In 2023 (figure 12), Greece's total natural gas consumption was approximately 67.6 terawatt-hours (TWh), equivalent to about 6.5 bcm. Of this total, 34.6% (23.4 TWh) was imported from Russia via the Sidirokastro pipeline. The Revithoussa LNG terminal played a crucial role, handling around 29 TWh from 42 LNG tankers, which accounts for 43.5% of Greece's total imports, with the United States and Russia being the primary suppliers. Imports from New Mesimvria amounted to 12.4 TWh, making up 18.5% of total imports, while Kipi contributed 2.4 TWh, or 3.4%. Figure 13 reveal that natural gas used for power generation constitutes the largest share of consumption at 50.9%. Exports and gas used for heating are nearly equal, with exports slightly surpassing heating gas at 25.3% and 23.9% respectively.

In 2022, the Revithoussa terminal expanded its capabilities by introducing small-scale LNG (SSLNG) services. This development included the opening of a truck loading station and a new jetty. The jetty supports the delivery of LNG via small vessels to a range of maritime users, including cruise ships, RO-PAX ferries, and large ships equipped with satellite storage and distribution units. This enhancement underlines the growing importance of regional neighbors in utilizing truck-loaded LNG for local energy requirements, given that smaller LNG volumes are more efficiently transported by truck rather than pipeline. Projections suggest that SSLNG consumption could increase significantly, from 0.07 bcm in 2022 to 0.4 bcm by 2031, representing a substantial 448% growth.

Figure 12: Yearly NNGS allocation data 2023 (DESFA, 2023)

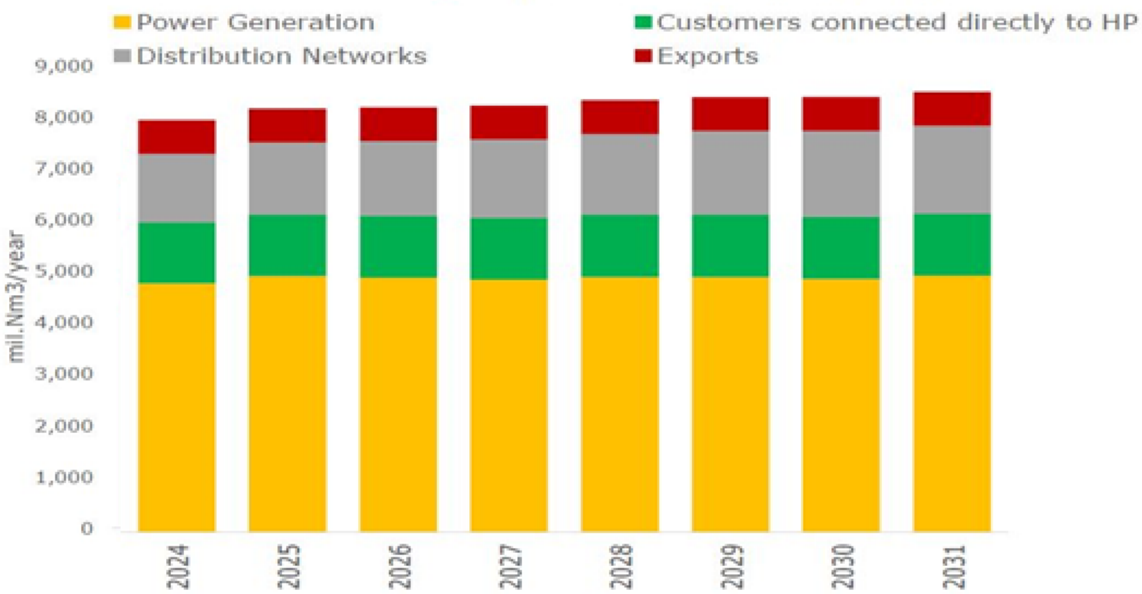
ΕΤΗΣΙΑ ΣΤΟΙΧΕΙΑ ΚΑΤΑΝΟΜΩΝ ΕΣΦΑ 2023 YEARLY NNGS ALLOCATION DATA 2023	
Μονάδα / Unit : kWh *Θερμοκρασία Καύσης Αναφοράς / Combustion Reference Temperature : 25 °C*	*Περίοδος / Period :* *01.01.2023 07:00 πμ/am - 01.01.2024 07:00 πμ/am*
ΕΘΝΙΚΟ ΣΥΣΤΗΜΑ ΜΕΤΑΦΟΡΑΣ ΦΥΣΙΚΟΥ ΑΕΡΙΟΥ (ΕΣΜΦΑ) / NATIONAL NATURAL GAS TRANSMISSION SYSTEM (NNGTS)	
(Α) Κατανεμηθείσες ποσότητες Φυσικού Αερίου στους Χρήστες στα Σημεία Εισόδου του ΕΣΜΦΑ / NG Quantities allocated to Users in the NNGTS Entry Points	67.663.292.739
ΚΗΠΟΙ / KIPI	2.302.823.383
ΑΓΙΑ ΤΡΙΑΔΑ / AGIA TRIADA	29.433.737.670
ΣΙΔΗΡΟΚΑΣΤΡΟ / SIDIROKASTRO	23.434.904.269
ΝΕΑ ΜΕΣΗΜΒΡΙΑ / NEA MESIMVRIA	12.491.827.417
(Β) Κατανεμηθείσες ποσότητες Φυσικού Αερίου στους Χρήστες στα Σημεία Εξόδου - Σημεία Εξόδου Αντίστροφης Ροής του ΕΣΜΦΑ / NG Quantities allocated to Users in the NNGTS Exit Points - Reverse Flow Exit Points	67.606.113.271
ΣΗΜΕΙΑ ΕΞΟΔΟΥ / EXIT POINTS	50.914.753.875
ΣΙΔΗΡΟΚΑΣΤΡΟ / SIDIROKASTRO	11.636.390.363
ΝΕΑ ΜΕΣΗΜΒΡΙΑ / NEA MESIMVRIA	5.054.969.033
ΤΕΡΜΑΤΙΚΟΣ ΣΤΑΘΜΟΣ ΥΦΑ / LNG TERMINAL	
(Γ) Ποσότητες και χώρα προέλευσης Υγροποιημένου Φυσικού Αερίου / Liquefied Natural Gas Quantities and country of origin	28.522.935.161
ΑΛΓΕΡΙΑ / ALGERIA	3.468.013.578
ΑΙΓΥΠΤΟΣ / EGYPT	3.504.626.798
Η.Π.Α. / USA	10.749.288.897
ΙΣΠΑΝΙΑ / SPAIN	511.504.225
ΝΙΓΗΡΙΑ / NIGERIA	935.560.094
ΝΟΡΒΗΓΙΑ / NORWAY	973.448.178
ΡΩΣΙΑ / RUSSIA	8.380.493.391
ΦΟΡΤΗΓΑ ΥΦΑ / TLS	
(Δ) Ποσότητες Φόρτωσης Φορτηγών ΥΦΑ & χώρα προορισμού / LNG Truck Loading Quantities & destination country	3.507.683
ΣΛΟΒΑΚΙΑ / SLOVAKIA	295.809
ΣΕΡΒΙΑ / SERBIA	883.444
ΒΟΡΕΙΑ ΜΑΚΕΔΟΝΙΑ / NORTH MACEDONIA	1.742.357
ΜΑΥΡΟΒΟΥΝΙΟ / MONTENEGRO	296.409
ΕΛΛΑΔΑ / GREECE	289.664

Figure 13: Greek natural gas market share 2023 (DESFA, 2023)



Looking ahead, Greece's annual natural gas demand is anticipated to surpass 8 bcm by 2030 (figure 14). This increase is expected to be driven by the expansion of new gas-fired power plants and the extension of distribution networks throughout the country, adding an additional 500 mcm of natural gas capacity in the next decade. Large companies directly connected to the High-Pressure Network have already reached a peak demand of 1,160 mcm. However, the ongoing geopolitical situation involving Russia and Ukraine may require DESFA to reassess its capacity to meet this demand reliably and efficiently in the future.

Figure 14: Natural gas demand prediction 2024-2031 (HAEE, 2022)



5.2 The Hellenic Energy Exchange (HEnEx) Natural Gas Trading Platform

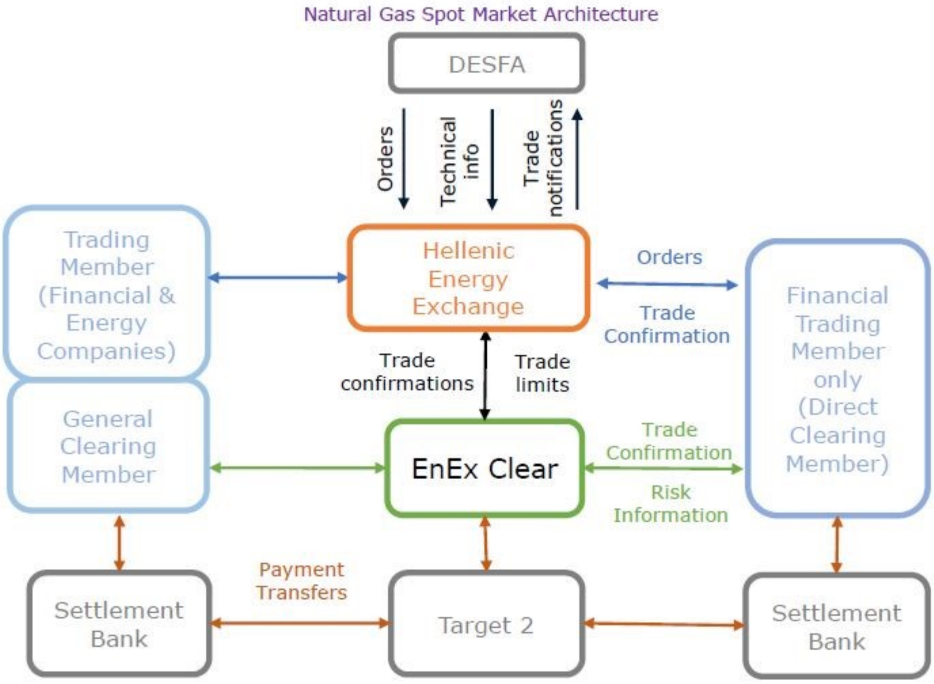
The newly introduced market model for natural gas features a structured Spot market designed to enhance trading efficiency and market transparency. This model includes a Virtual Trading Point (VTP) offering products for the current and the next three Gas Days. The platform integrates Central Clearing through a dedicated Clearing House, which facilitates system balancing, maintains trading anonymity, and supports Continuous Trading and Auctions. This setup aims to foster a dynamic and effective trading environment.

Since its launch in early 2022, the Trading Platform has been shaped by ten Regulatory Decisions and has undergone a series of Dry Runs to ensure its operational readiness. The platform is poised to broaden its range of offerings to include longer-term products, such as quarterly, semi-annual, annual, or seasonal contracts. The development of such a futures market will depend on the successful establishment of a sufficiently liquid spot market, which is essential for providing reliable price signals and reference prices needed for future trading.

Participants on this new Platform must secure capacity through approval from the Hellenic Energy Exchange (HEnEx), adhering to the specific terms set out in the Rulebook. Approved participants may also take on the role of Liquidity Providers. Notably, both participant and Liquidity Provider roles are non-transferable, ensuring consistent and reliable market activity. Liquidity Providers are responsible for placing orders that accurately reflect the available market information.

Participants have the option to either act as Direct Clearing Members or utilize the services of a General Clearing Member for transaction clearing. The Natural Gas Transmission System Operator (TSO), DESFA, is integral to this framework, actively placing orders and supplying essential technical information. Additionally, DESFA participates in trading on the platform to support balancing actions, operating within the platform's regulations and reinforcing the interconnected nature of operational roles and regulatory compliance in the trading ecosystem.

Figure 15: Natural Gas Spot Market Architecture (HAEE, 2022)

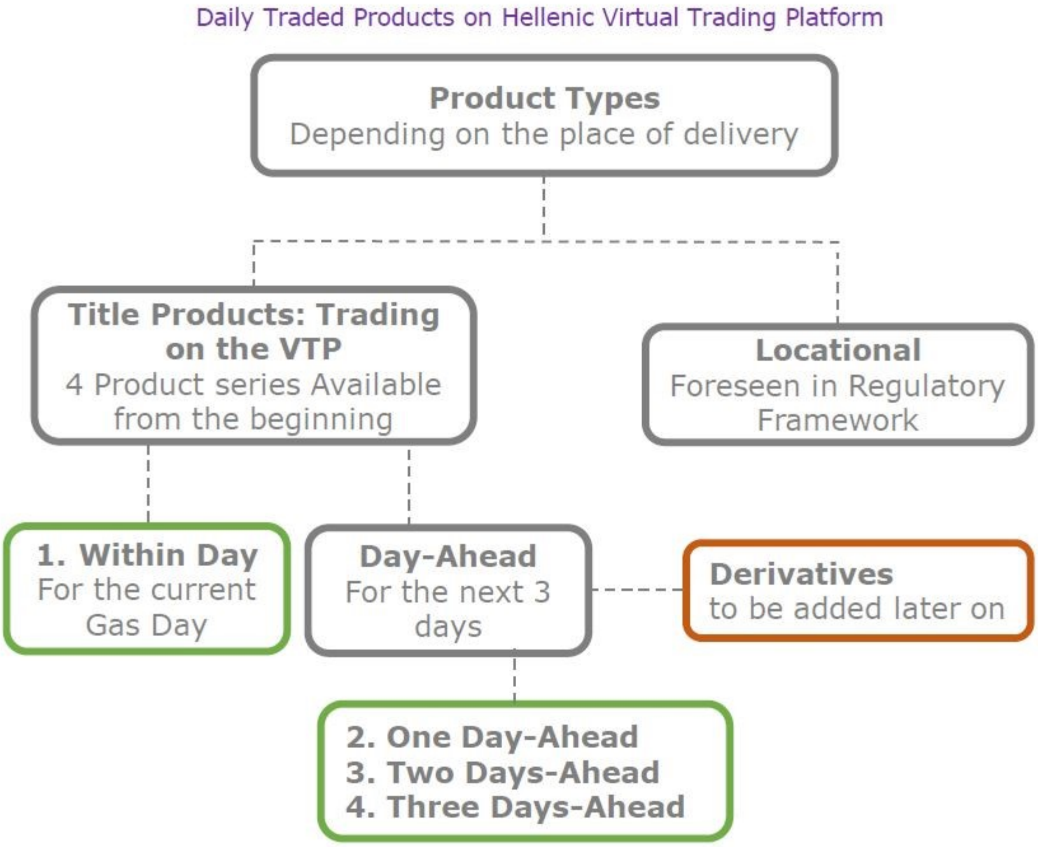


The newly established Trading Platform for natural gas operates with a standard Gas Day running from 06:00 CET on day D to 06:00 CET on day D+1. The platform provides four distinct product series at the Virtual Trading Point (VTP). Its key innovation is the integration of Continuous Trading with occasional Call Auctions, allowing for a fluid trading experience. Continuous Trading is the primary method used, but the platform also accommodates ad-hoc auctions initiated by the TSO to address specific balancing requirements.

This advanced setup represents a departure from the previous auction-centric Balancing Platform, streamlining the process for acquiring or selling balancing quantities. The new model ensures a more efficient and responsive approach to managing gas balances.

Furthermore, the platform supports the registration, clearing, and settlement of pre-negotiated trades among participants through the Clearing House. This system not only improves market efficiency but also enhances the overall participant experience by ensuring robust and transparent transaction processing.

Figure 16: Daily Traded Products on Hellenic Virtual Trading Platform (HAEE, 2022)



HEnEx provides Reference Prices to monitor current gas values within the Greek High-Pressure Transmission System (HTP). The platform calculates several key Reference Values:

1. **Closing Price**:
    - **Timing**: Available daily at 01:45 CET.
    - **Details**: Four closing prices are computed each day, one for each Gas Day in question.
    - **Methodology**: These prices are derived as the volume-weighted average of the final transactions that account for 30% of the total volume for each respective Gas Day.
2. **HGSIDA**:
    - **Timing**: Published daily at 18:15 CET.
    - **Details**: Represents the volume-weighted average of transactions occurring between 07:00 and 18:00 CET for the following Gas Day.

3. **HGSIWD**:

   - **Timing**: Also available daily at 18:15 CET.
   - **Details**: Reflects the volume-weighted average of transactions between 07:00 and 18:00 CET for the current Gas Day.

The platform primarily employs Continuous Trading, complemented by the flexibility for DESFA to initiate auctions to fulfill balancing needs. Additionally, it streamlines the registration, clearing, and settlement of pre-negotiated trades through the Clearing House.

HEnEx is tasked with computing and publishing the Buy and Sell Marginal Prices for the Gas Balancing Market in compliance with Regulation (EU) 312/2014. It establishes a maximum price spread of 1.6 €/MWh for day-ahead (D) trades and 1.2 €/MWh for trades from one to three days ahead (D+1/+2/+3). The platform plans to reduce these spreads to 1.2 €/MWh and 0.8 €/MWh, respectively, following an initial nine-month period.

Clearing Procedures: Clearing of transactions on the HEnEx Natural Gas Trading Platform is managed by EnExClear and its Clearing Members. EnExClear conducts daily calculations at 14:00 CET to determine the net position—credit or debit—for each Clearing Member and Account, based on transactions from the previous Clearing Day up to the current one. Net debit positions are settled the next working day (C+1), while net credit positions are settled two working days later (C+2). EnExClear maintains transparency by providing detailed transaction reports and issuing daily invoices. Direct and General Clearing Members are required to meet stringent financial, organizational, operational, and technical criteria to ensure a secure and effective clearing process.

5.3 The 5 key elements and the 3 Main Indicators

Since its inception in March 2022, the HEnEx Trading Platform has welcomed 25 market participants. In its first year, the platform recorded a total traded volume of 2.87 TWh, with an average natural gas price of €113.57/MWh (as depicted in Figures 14 and 15). By 2023, the traded volume surged to 8.99 TWh, and the average price decreased to €40.62/MWh (illustrated in Figures 16 and 17).

Greece's natural gas prices have mirrored global market trends, experiencing significant volatility. This fluctuation was influenced by various factors, including the COVID-19 pandemic and geopolitical tensions, notably the ongoing conflict in Ukraine that began in February 2022. These events led to unprecedented price spikes compared to previous years. However, as shown in figure 20, by 2023 prices started to stabilize, though they remained relatively high.

Figure 17: Trading Volume per Contract 2022 (HenEx, 2024)

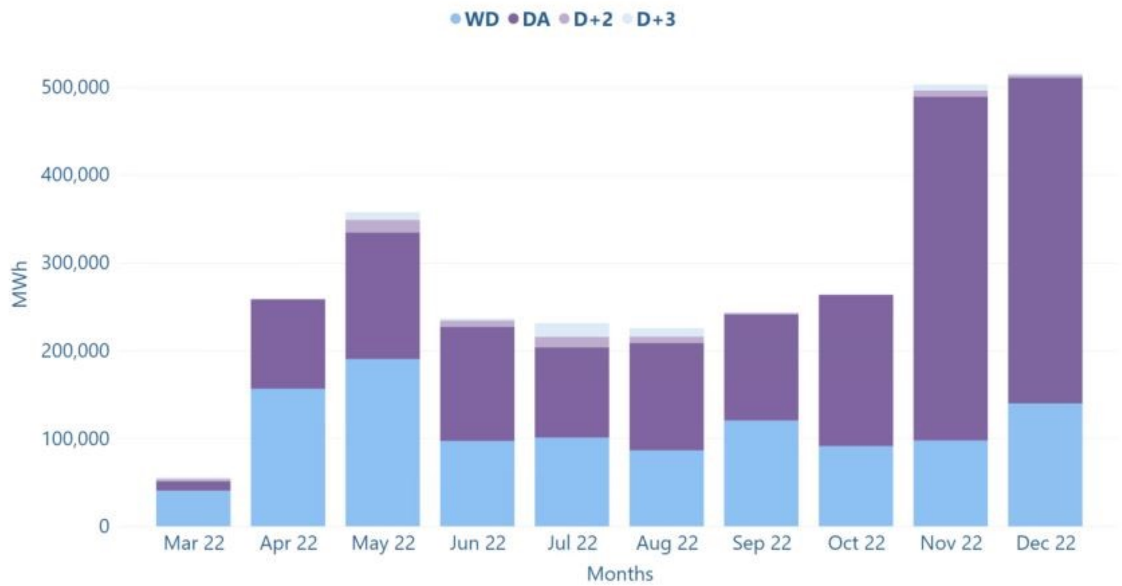


Figure 18: HEnEx NGAS indices 2022 (HenEx, 2024)

Figure 19: Trading Volume per Contract 2023 (HenEx, 2024)

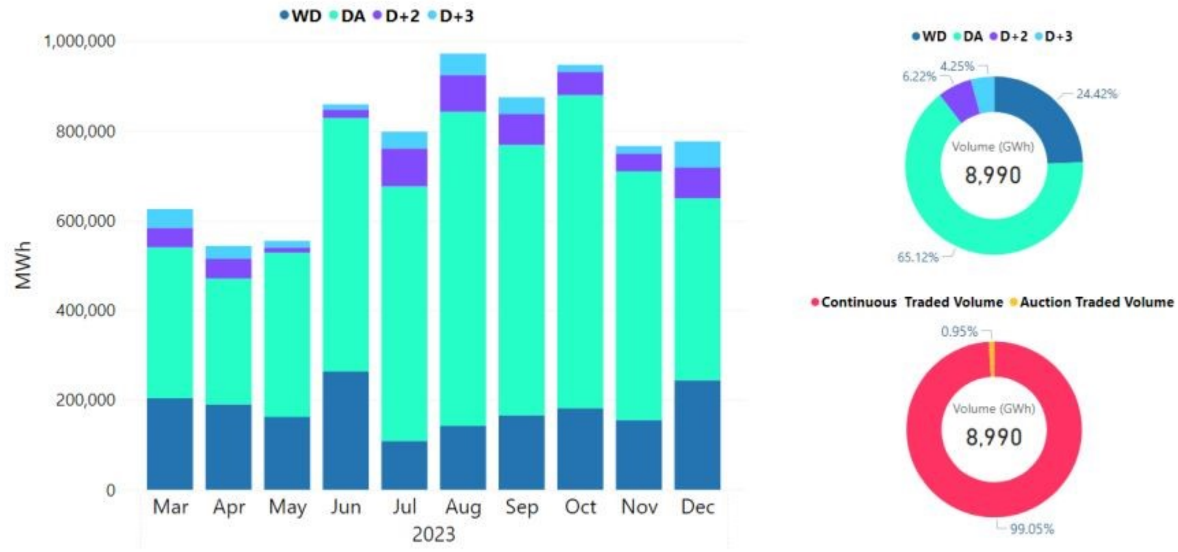


Figure 20: HEnEx NGAS indices 2023 (HenEx, 2024)

The 5 key elements (2023)

1. Market Participants: 25
2. Traded Products:
   i) Within-Day (WD),
   ii) Day-Ahead (DA), Day +2, Day +3
3. Traded Volumes: 8,990 TWh
4. Tradability Index: Insufficient Data
5. Churn Rate:
   i) Net Churn = Total Traded Volume/Consumption in hub area = 8,990 TWh/49,32 TWh = 0,18
   ii) Gross Churn = Total Traded Volume/Demand in hub area (Consumption + Exports) = 8,990 TWh/ 66,02 TWh = 0,14

It is notable to refer Total Traded Volumes don't include OTC trades concluded on TSO platform and not on HEnEx platform, because OTC trades concluded on TSO platform since the start of HEnEx platform are not available. Additionally, Total Traded Volumes for January and February of 2023 are not available.

Considering what was mentioned in chapter two about the 5 Key Elements it is clear that Greek hub is at an early enough stage to be called 'mature'.

The 3 Main Indicators (2023)

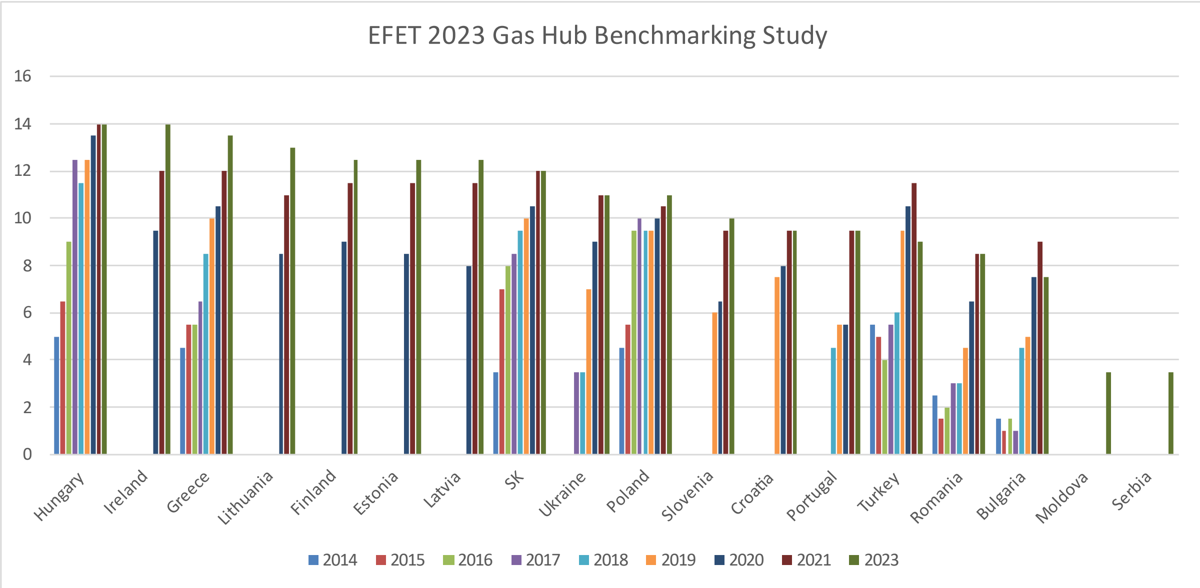
As detailed in Table 10, the latest EFET Gas Hub Development Study reveals that Greece achieved a score of 13.5 out of 20 in the evaluation of three main indicators. This places Greece ahead among emerging gas trading hubs in Southeast Europe, alongside Turkey, Bulgaria, and Romania. The EFET Annual Scorecard 2023 (Figure 21) highlights Greece's substantial progress over the past nine years, underscoring its leadership in developing a well-established regional gas trading hub in Southeast Europe.

Table 10: The 3 Main Indicators scoring process of Greece_2023

Criteria	Heading 2023	Greece
1.a	Transparency and consultation	1
1.b		1,5
2	Entry-exit system established	1
3	Title Transfer	1

4	Cashout rules (long short positions imbalances set to zero at the end of the day with payment/receipt of imbalance charge in local currency/MWh)	1
5	TSO system balancing	1
6.a	Licensing and reporting obligations	1
6.b	Market interference	1
7	Resolve market structural and concentration issues (defined role for historical player if flexibility/liquidity is scarce)	1
8	NRA fees or Hub fees (not fees relating to participating on a exchange or trading platform)	1
9	Establish a reference price at the hub for contract settlement in the event of default	1
10	Standardised contract	1
11	Price Reporting Agencies producing daily prices at the hub	0
12	Voluntary market makers operating at the hub	0
13	Brokers	0
14	Establishment of exchange	1
15	Hub price becomes reliable and used as benchmark	0
16	Hub spot (shorter than monthly products) liquidity	0
Total		13,5

Figure 21: Gas Hub Benchmarking progress (EFET, 2023)



5.4 Road to maturity

Forecasting the evolution of a gas price regime in Greece's developing gas hub remains speculative at this stage, given that sufficient regional gas supplies have yet to become available. However, ongoing infrastructure projects and growing interest from European enterprises indicate a likely surge in cross-border trading activities. Once interconnections are established and an efficient gas exchange mechanism is operational, traders will likely engage in buying and selling marginal gas quantities through the hub. This activity could foster a competitive pricing environment, compelling traditional suppliers to reconsider their contract rates.

The availability of gas volumes will play a crucial role in shaping the hub's effectiveness. Conventional suppliers might limit gas availability to control the hub's influence. For non-traditional or new suppliers, opportunities may arise to fill this gap. Potential sources include Turkey, which occasionally has surplus gas, the Shah Deniz consortium, which might offer some of its gas volumes to the spot market, and LNG suppliers utilizing Greece's terminals, such as Revithoussa, Alexandroupolis, and planned FSRUs. Consequently, the Greek hub is anticipated to enhance wholesale markets by channeling gas at competitive rates.

The Turkey-Greece Interconnection (ITG), the Trans Adriatic Pipeline (TAP), and the Greek-Bulgaria Interconnector (IGB), along with other regional interconnectors such as those between Bulgaria and Romania, Bulgaria and Serbia, and Turkey and Bulgaria, will form a gas corridor linking Caspian and Middle Eastern resources to European markets. The Shah Deniz consortium's choice of TAP as its route to Europe solidifies Greece's role as a key transit point in the Caspian gas export chain and may stimulate further infrastructure development and market growth.

Initially, market integration will benefit from the existing Interconnector Greece-Turkey, which already transports Azeri gas to Greece via Turkey. While there are no immediate plans for reverse flow capabilities for the ITG, such a project would significantly enhance market integration. Over the next decade, gas resources from the East Mediterranean, especially from Israel and Cyprus, are expected to supply substantial quantities to the European energy grid, potentially matching or exceeding those from Azerbaijan.

To establish a reliable price index, a sufficient volume of spot gas trading must occur in the region. The development of a mature gas trading hub should account for these factors, as the majority of gas flow and trade will eventually funnel through the Turkish, Greek, and Bulgarian transmission systems.

Currently, Bulgaria's TSO, Bulgartransgaz, is collaborating with Greece's DESFA on interoperability and market integration issues. DESFA coordinates with Bulgartransgaz on matters related to the Balancing Code, network code interoperability, and data exchange rules.

Considering the positive developments in Greek-Bulgarian cooperation and an assessment of the gas market dynamics in Greece, Bulgaria, and Turkey, Greece is well-positioned to lead in operating a mature regional Gas Trading Hub for several reasons:

1. **Increased Liquidity**: The Greek market is poised to achieve greater liquidity compared to Bulgaria due to the operation of two FSRU units and the anticipated functionality of the South Kavala Gas Storage facility.

2. **Strategic Axis**: The Komotini-Alexandroupolis corridor, which extends from the Greek-Turkey interconnector, is set to be a key area for gas movements. This axis is expected to offer more advantages than Bulgaria's Varna-Sofia axis, thanks to its multiple entry and exit points and significant gas storage capacity.

3. **Regulatory Advantages**: A Greek Gas Trading Hub offers benefits over a Turkish one, particularly in Istanbul, due to Greece's EU membership. The EU's legislative, fiscal, and tax regimes, along with a stable regulatory framework, provide full open access to infrastructure and market operations.

4. **Export Opportunities**: Traders have shown interest in exporting gas to Turkey via the Greece-Turkey Interconnector (IGT), with Greece's regulatory framework allowing for virtual reverse flow even when physical reverse flow capabilities are not in place.

Chapter 6: Conclusions and next steps

This thesis explores the potential for the Greek region to evolve into a well-established gas hub, considering the recent trend of establishing additional regional hubs across Europe. The analysis begins with a review of the dynamics and features of existing gas hubs in Europe, followed by a focus on the unique aspects specific to Southeast Europe.

The global gas market has undergone a significant transformation in recent years, shifting away from traditional long-term take-or-pay contracts linked to oil prices. The current trend favors shorter-term agreements without destination constraints, with pricing increasingly reflecting the real-time balance of supply and demand for natural gas. This departure from oil-linked pricing has led to a surge in spot gas trading, particularly in European markets.

European gas trading has advanced with the development of both physical and commercial trading hubs. Physical hubs are characterized by their extensive infrastructure, including import and export pipelines, interconnectors, storage facilities, and title transfer systems. Commercial hubs, on the other hand, facilitate market-driven price formation through bilateral agreements, broker-based transactions, exchange trading, futures contracts, and financial derivatives.

Over the past decade, a noticeable disparity has emerged between spot prices at these hubs and prices from long-term oil-indexed contracts, as historical data reveals. As the European gas market seeks to accommodate diverse supply demands and integrate planned transit routes and interconnectors in Southeast Europe, there is a clear push to enhance market liquidity through the development of gas trading hubs. This move supports the expansion of storage capacity and new LNG terminals, contributing to a significant increase in available gas volumes in the near to medium term.

Several key factors influence the development of gas trading hubs, including pipeline corridors, interconnectors, and LNG terminals (both land-based and Floating Storage and Regasification Units, or FSRUs). Despite positive progress, future gas demand growth is expected to be moderate, posing challenges for reaching markets further west or competing in Turkey. Delivering gas to major northern European markets involves longer distances, which lead to higher transportation costs and lower netbacks.

In this context, LNG plays a crucial role in diversifying supply sources and routes in Southeast Europe, thereby enhancing energy security. Increased LNG utilization provides pricing flexibility and ensures safer transit. Furthermore, secure LNG supplies can support ongoing investments in gas pipelines.

The groundwork for developing one or more gas trading hubs in Southeast Europe is already in progress, with countries like Greece, Bulgaria, Romania, and Turkey exploring their potential. Greece, despite being in the early stages of hub development, benefits from a favorable geopolitical position. Key projects such as the Interconnector Greece-Bulgaria (ICGB), the Trans Adriatic Pipeline (TAP), the Revithoussa LNG Terminal, the Alexandroupolis Floating Storage Regasification Unit (FSRU), and the Hellenic Energy Exchange (HEnEx) natural gas platform position Greece as a leading candidate for establishing a regional gas hub. However, Greece must complete planned infrastructure projects, including the EastMed pipeline, additional interconnectors, and the South Kavala underground storage facility, to solidify its role as a regional reference point. Success will also depend on strong cooperation with neighboring countries.

The European Union plays a crucial role in this development by ensuring a regulatory environment that supports free and competitive gas trade across member states. The creation of one or more regional gas trading centers in the medium term will depend on expanding market liquidity significantly. Lessons from existing European gas trading hubs highlight the importance of market liberalization, political will, cultural adaptation, regulatory reforms, and effective governance. Competition among gas hubs is expected, with success contingent on their ability to offer cost-effective and high-quality services, thereby enhancing the efficiency and resilience of the regional gas trading landscape.

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