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Global Gas and LNG Markets: Demand, Supply Dynamics, and Implications for the Future

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Abstract: This article offers a comprehensive analysis of the global gas and liquefied natural gas (LNG) markets, discussing increasing demand, market volatility, supply and demand dynamics, and the implications of the Paris Agreement on natural gas demand. It emphasizes the potential impacts of decarbonization policies on the LNG market, including changes in energy composition, reduced LNG demand, increased costs, and the need for industry adaptation. The article also examines the future outlook, investment needs, and implications for global gas and LNG markets, highlighting the continued uptake of gas in heavy-duty transport and the importance of investment to avoid supply–demand gaps. Overall, the analysis provides insights into the complex dynamics and challenges facing the global gas and LNG markets in the context of energy transition and climate change mitigation efforts.

Keywords: global gas market; LNG market; decarbonization policies; energy transition; investment; climate change mitigation

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1. Introduction

Market volatility is a key driver of energy security concerns. It can potentially disrupt the supply of energy resources, leading to price spikes and market imbalances [1]. The COVID-19 pandemic has also contributed to market volatility in the energy sector, as the global economic slowdown has reduced demand for oil and gas, leading to a drop in prices [2].

The impacts of market volatility on energy security can be long-lasting. For example, in the aftermath of the 2008 financial crisis, many countries implemented policies to promote renewable energy and energy efficiency in order to reduce their dependence on volatile fossil fuel markets [3]. These policies have had a lasting impact on the energy landscape, with renewable energy now accounting for a significant share of global electricity generation [4].

To address market instability and energy security worries, worldwide policies have been enacted. The International Energy Agency (IEA) has urged greater investment in renewable energy and efficiency to decrease reliance on fossil fuels [5]. The European Union has introduced directives, such as the Renewable Energy Directive and the Emissions Trading System, to encourage renewable energy and diminish greenhouse gas emissions [6].

The Shell LNG Outlook 2023 predicts significant market volatility in the global energy industry. This volatility will trigger interventions to enhance energy security but will have lasting economic and emissions impacts. Europe is expected to benefit from the flexibility of the LNG industry in 2022, as the continent increases its LNG imports by 60% to 121 million tons to offset lower Russian pipeline imports. The US is expected to grow global supply by 6 million tons. Market volatility remains a barrier to achieving energy security, but policy interventions promoting renewable energy and energy efficiency can help mitigate the impacts of market disruptions [7].

A comprehensive overview of the LNG market shows that continued market volatility and the uncertainty of global energy demand growth will drive policymakers to focus on enhancing energy security and promoting renewable energy alternatives. As the world transitions towards a low-carbon future, LNG will play an important role in meeting the world's energy needs. However, the industry must adapt to changing market dynamics and invest in cost-competitive energy alternatives to remain competitive and sustainable.

While this article offers a comprehensive analysis of the global gas and liquefied natural gas (LNG) markets, there exists a need to clearly delineate the knowledge gap and underscore the significance of this study. Specifically, a more explicit elucidation of the precise gaps in current understanding pertaining to market dynamics, supply-demand interplay, pricing mechanisms, and the long-term ramifications for the global gas and LNG sectors. By addressing these knowledge gaps, the present research endeavours to enrich scholarly discourse and enhance comprehension of the intricate challenges and potentialities within the dynamic energy landscape, particularly concerning gas and LNG markets.

The reliable matching of supply and demand is a critical concern in the natural gas market. While short-term price fluctuations can pose immediate challenges, ensuring the long-term security of the natural gas supply is equally important. This study addresses the overarching issue of achieving a sustainable balance between supply and demand in the natural gas industry [8]. The volatility of natural gas prices in the short term can result from various factors, including market dynamics, geopolitical events, and weather patterns. These fluctuations can impact the profitability of gas producers, influence investment decisions, and potentially disrupt the stability of energy markets. However, it is essential to recognize that short-term price variations are just one aspect of the natural gas sector's broader challenge [9].

To ensure the long-term security of the natural gas supply, it is crucial to assess the resilience and adequacy of the infrastructure and resources that support its production, transportation, and distribution. This includes examining reserves and reserves-to-production ratios, infrastructure capacity, geopolitical risks, technological advancements, and environmental considerations [10]. By understanding and addressing these factors, policymakers, industry stakeholders, and researchers can develop strategies to mitigate supply-demand imbalances and enhance the stability and security of natural gas supply in the long run.

A comprehensive review of existing literature, reports, and data on global gas and liquefied natural gas (LNG) markets was conducted to conduct the analysis presented in this research. The following materials and methods were employed: Data Collection, data on global gas and LNG markets, including supply and demand dynamics, market trends, and investment opportunities, were collected from reputable sources, such as international energy agencies, industry reports, and scholarly publications. A thorough review of relevant literature was conducted to gather insights into the current state of global gas and LNG markets and emerging trends and challenges. The literature review involved identifying key studies, reports, and academic papers that provided valuable information on the subject [11].

The analysis also identified challenges and investment opportunities in the global gas and LNG markets. The market outlook was based on the analysis of the collected data, and a comprehensive market outlook was developed, highlighting the expected trends, challenges, and investment opportunities in the global gas and LNG markets. The outlook considered factors such as supply and demand dynamics, market volatility, energy security interventions, and economic and emissions impacts. The findings from the analysis and market outlook were synthesized to conclude the implications for the future of global gas and LNG markets. Key insights, challenges, and investment needs were identified and discussed in the context of the evolving energy landscape.

In this study, we will delve into the multifaceted nature of the natural gas market, considering both short-term price fluctuations and the long-term security of supply. By analyzing the interplay between supply and demand dynamics, exploring market trends,

and evaluating key factors affecting the industry, we aim to provide insights and recommendations to ensure a sustainable and secure natural gas market for the future.

2. Literature Review

The global gas and liquefied natural gas market is influenced by various factors, including the transition to cleaner energy sources, emerging Asian markets, and renewable energy policies. This systematic review aims to consolidate the existing literature to gain insights into the complex dynamics of the global gas and LNG market, encompassing demand drivers, market competition, and the role of major LNG importers.

Multiple studies highlight the significance of emerging Asian markets and the transition to clean energy in driving the global demand for gas and LNG. Zou (2022) emphasizes the pivotal role of emerging Asian countries in determining the scale of new LNG projects globally [12]. Fulwood (2020) identifies the potential for smaller Asian markets to contribute significantly to LNG demand in the coming decades [13]. Additionally, Najm (2020) demonstrates the negative impact of renewable energy adoption on the LNG trade, emphasizing the importance of investing in cleaner energy technologies to reduce global LNG trade [11].

Insights from several studies shed light on the dynamics of the global gas and LNG market. Liu (2020) attributes Australia's LNG export performance to the Competitiveness Effect [6]. Chernyaev (2020) explores the current state of the LNG market, focusing on Russia's role as an energy resource provider [14]. Merkulov (2020) examines global LNG production capacities, including regional structures and the influence of environmental regulations [15]. Chen (2021) analyzes historical trends in global LNG pricing and provides recommendations for China's LNG import pricing mechanism. These studies indicate that the global LNG market is becoming increasingly competitive, necessitating strategies to accommodate new players, expand markets, and adapt to evolving pricing mechanisms [16].

Consistent findings across the reviewed papers identify China, India, Japan, South Korea, and Taiwan as the largest LNG importers globally. Vivoda (2014) and Vivoda (2019) discuss these five countries' approaches to diversifying LNG imports [17,18]. Norman (2019) highlights explicitly China's emergence as a major LNG importer due to its transition to cleaner fuels [19]. Shaikh (2016) assesses the stability of LNG supplies in the Asia Pacific region, considering the five largest importers [3]. This literature supports the notion that these countries will continue to perform substantial roles in the global LNG market.

This systematic review (Table 1) provides a comprehensive overview of the global gas and LNG market dynamics, addressing demand drivers, market competition, and the significance of major LNG importers. The findings underscore the importance of understanding the complex interplay between economic, environmental, and policy factors that shape the global gas and LNG landscape. Further research should focus on monitoring market developments, evolving pricing mechanisms, and the potential impact of emerging energy technologies on the future of the gas and LNG market.

Table 1. Key Authors and Contributions in the literature review on Global Gas and LNG Market Dynamics.

Authors	Year	Key Contributions
Zou et al., 2022 [20]	2022	Emphasizes the pivotal role of emerging Asian countries in determining the scale of global LNG projects.
Fulwood, 2020 [13]	2020	Identifies the potential for smaller Asian markets to significantly contribute to future LNG demand.
Najm et al., 2020 [19]	2020	Demonstrates the negative impact of renewable energy adoption on LNG trade, highlighting the need for cleaner energy technologies.
Liu et al., 2020 [21]	2020	Attributes Australia's LNG export performance to the Competitiveness Effect.

Table 1. *Cont.*

Authors	Year	Key Contributions
Chernyaev et al., 2020 [14]	2020	Explores the current state of the LNG market, focusing on Russia's role as an energy resource provider.
Merkulov et al., 2020 [11]	2020	Examines global LNG production capacities, including regional structures and the influence of environmental regulations.
Chen et al., 2021 [16]	2021	Analyzes historical trends in global LNG pricing and provides recommendations for China's LNG import pricing mechanism.
Vivoda et al., 2014, 2019 [12,18]	2014, 2019	Discusses the approaches of China, India, Japan, South Korea, and Taiwan to diversify LNG imports.
Norman, 2019 [22]	2019	Highlights China's emergence as a major LNG importer due to its transition to cleaner fuels.
Shaikh et al., 2016 [10]	2016	Assesses the stability of LNG supplies in the Asia Pacific region, considering the five largest importers.

3. The Paris Agreement and Natural Gas Demand

The Paris Agreement, adopted in 2015 under the United Nations Framework Convention on Climate Change (UNFCCC), represents a global effort to address climate change and limit global temperature rise to below 2 degrees Celsius above pre-industrial levels. This text evaluates the climate policy measures outlined in the agreement and their potential impact on the demand for natural gas and the long-term gas market [23].

The Paris Agreement promotes a range of climate policy measures to achieve its objectives, including mitigating greenhouse gas emissions, promoting renewable energy sources, improving energy efficiency, and encouraging sustainable practices. These policies directly affect the energy sector and can influence the demand for natural gas as a transitional fuel [24].

While the Paris Agreement emphasizes the importance of transitioning to low-carbon and renewable energy sources, it acknowledges the role of natural gas as a cleaner alternative to more carbon-intensive fuels, such as coal. The agreement recognizes that natural gas can serve as a bridge fuel during the transition to a low-carbon economy. However, the long-term implications of the Paris Agreement on gas demand are complex and depend on various factors, including the implementation of climate policies, technological advancements, and the competitiveness of renewable energy sources.

The long-term market dynamics of natural gas are likely to be influenced by the implementation of the Paris Agreement. The growing focus on carbon neutrality and the increased adoption of renewable energy technologies may shift the energy mix, impacting gas demand. This shift may require the gas industry to adapt its strategies, explore new markets, and invest in technologies, such as carbon capture and storage (CCS), to mitigate greenhouse gas emissions from gas production and utilization [25]. The Paris Agreement represents a critical milestone in global efforts to address climate change. While the agreement's climate policies may have implications for gas demand in the long term, natural gas is expected to play a role in the transition to a low-carbon economy. The gas industry should anticipate and adapt to evolving market dynamics, leveraging technological advancements and sustainable practices to align with the goals outlined in the Paris Agreement [26].

Although switching to low-carbon and renewable energy sources is essential, the agreement also recognizes the importance of natural gas as a cleaner alternative to coal during the transition. The agreement's long-term effects on natural gas demand will rely on various variables, including how well policies are implemented, how quickly technology develops, and how competitive renewable energy sources are. The energy mix may change as the emphasis on carbon neutrality and renewable energy grows, which could impact the demand for natural gas. The gas business must adapt, look into new markets, and spend money on carbon capture and storage technology to reduce emissions. Despite

these modifications, it is anticipated that natural gas will still play a part in the shift to a low-carbon economy [4].

4. Overview of the LNG Global Market

The global liquefied natural gas market has experienced significant disruption and unprecedentedly high prices following Russia's invasion of Ukraine in February 2022, which led to a decline in Russian pipeline gas shipments to the European Union. The resulting high demand for LNG from EU buyers led to record global spot prices and a reduction in the volume of LNG available to developing economies.

The LNG market is facing new risks to demand growth due to high prices and supply disruptions, leading to delays and cancellations of proposed LNG import projects in Asia. Additionally, key LNG growth markets are implementing new policies to reduce dependence on global gas imports, which could negatively impact long-term demand in regions expected to drive robust growth in the LNG industry.

In contrast, European countries have increased their LNG imports to compensate for Russia's declining pipeline gas shipments. However, the EU's climate and energy security policies are expected to reduce gas demand by at least 40% through 2030, which could cause a potential fall in LNG demand after 2023. Europe's import capacity could increase by a third by the end of 2024 through the addition of new LNG terminals. Still, this new capacity may go unused because of the continent's energy transition objectives [27].

High prices, COVID-19 shutdowns, slower economic growth, and rising concerns about fuel supply security and affordability are all causing Japan, South Korea, China, and South Asia to reduce their LNG purchases. Instead, they rely more on alternative energy sources, such as nuclear, wind, and solar power generation, lower-cost Russian pipeline imports, and domestic gas production [28]. Southeast Asia faces challenges due to high prices, limited LNG contract availability, and infrastructure constraints. Long-term contracts with delivery dates prior to 2026 are said to be sold out globally, leaving price-sensitive Southeast Asian buyers vulnerable to volatile and expensive spot markets.

The global gas and LNG markets are expected to evolve as market dynamics point to a structural change. The market is expected to remain tight until the mid-2020s as Europe and Asia compete for limited new LNG supply. The LNG supply is expected to reach 80 million tons, 60% of the total gas supply of 140 million tons. However, gas and LNG prices are expected to hit record levels in 2023 due to reduced gas imports from Russia, which will increase the use of coal in power generation in Germany [9].

As a result of high prices, industrial users in major European markets are expected to reduce their average gas use by 16% compared to 2021. LNG could become a core energy supply for Europe to meet its energy security needs. In 2023, China's LNG imports are expected to fall by 15 million tons (or 19%) following strict COVID measures. Similarly, South Asian LNG imports are expected to drop by 5.8 million tons due to high prices [29].

The global LNG trade is expected to rise to 397 million tons, an increase of 16 million tons compared to 2021. There will be continued uptake of gas in heavy-duty transport, and the majority of new LNG supply to 2030 is expected to come from the US and Qatar. However, without further investment, a supply-demand gap will still loom.

The impact of high LNG prices will spur fuel switching, including coal use in Asia, which will have an impact on global emissions. The number of operating LNG vessels is expected to increase to 521, while there are 130 LNG vessels on order. There are currently 635 LNG fueling stations in Europe, some with Bio LNG and 39,600 LNG and Bio LNG fueled vehicles. China is expected to provide more flexibility to the global LNG market [30].

The International Energy Agency (IEA) has reported that natural gas markets worldwide continued to tighten in 2022 despite a 1.6% decline in global consumption. The demand for natural gas is projected to remain unchanged in 2023, but Russia's future actions and fluctuating energy prices make the outlook uncertain [29]. Europe's gas demand decreased by 13% and Asia's by 2% due to high liquefied natural gas (LNG) prices, COVID-19-related disruptions in China, and mild weather conditions in Northeast Asia [8].

Global LNG trade will have more than doubled to USD 450 billion by 2022, with traded volumes increasing by 6%. On the other hand, the modest 5.5% increase in supply was due to maintenance at large liquefaction ports and a long outage at Freeport in the United States [20]. According to the IEEFA, global LNG prices will remain structurally high for several years due to weak supply growth and strong demand. Global LNG markets may remain tight until significant new supply comes online later this decade, causing periodic disruptions, according to McKinsey and Company's Global LNG Market Outlook report [27].

According to the same report by McKinsey and Company (2021), the COVID-19 pandemic has accelerated structural shifts in the energy sector, particularly the transition towards cleaner and more diversified energy sources. The report suggests that LNG stakeholders should adapt to these shifts by investing in low-carbon technologies and exploring new business models that can deliver value in a changing market.

As the global LNG industry continues to expand, the risk of oversupply remains a critical concern for market participants, including producers, traders, and investors. The COVID-19 pandemic and its impact on global energy demand have added further uncertainty to the market, highlighting the need for LNG industry stakeholders to remain vigilant and agile in responding to evolving market dynamics.

One potential strategy for mitigating the risk of oversupply is to focus on developing new markets and diversifying demand sources. This could involve targeting emerging markets with strong long-term growth potential, such as Southeast Asia, India, and Latin America, where demand for cleaner and more efficient energy sources is increasing rapidly. In addition, efforts to promote LNG as a transportation fuel, particularly in the marine and heavy-duty road transport sectors, could create new demand sources and reduce reliance on traditional power generation markets [28].

Another critical factor for maintaining market stability and avoiding oversupply is effective coordination between industry stakeholders, including producers, traders, and regulators. Collaboration on infrastructure development, investment planning, and risk management can help ensure that new supply additions are balanced with corresponding increases in demand and adequate infrastructure to support efficient and cost-effective distribution.

Global LNG markets are expected to have limited supply additions in the coming years, and high prices will continue to lower Asian demand growth, particularly among price-sensitive emerging markets. European policymakers are taking aggressive measures to cut gas consumption and meet emissions reduction targets, which are likely to stabilize and reverse LNG demand growth on the continent later in the decade [27].

Along with declining gas consumption in Europe and global investments in cost-competitive energy alternatives, a supply glut may result in lower-than-anticipated prices, smaller netbacks, tighter margins, and lower profits for LNG exporters. These factors include high prices, weak LNG demand growth, and elevated price sensitivity in Asia. While the growth prospects for the global LNG market remain robust, industry stakeholders must remain vigilant in managing the risks associated with oversupply and market volatility. Diversifying demand sources, promoting the use of LNG in new sectors, and collaborating effectively across the value chain will be critical to ensuring long-term market stability and profitability [5].

As the industry navigates these challenges, Europe's increased LNG imports and flexibility may stabilise the market. The region is expected to increase its LNG imports to offset lower Russian pipeline imports, which could relieve exporters facing weaker demand growth in other regions. Moreover, Europe's commitment to reducing greenhouse gas emissions through policies promoting renewable energy and energy efficiency may create new opportunities for LNG as a transition fuel. The next section will explore Europe's increased LNG imports and flexibility in more detail [6].

Natural gas is a vital source of energy for many countries around the world. According to the International Energy Agency (IEA), global natural gas consumption has steadily increased over the past decade, with demand expected to continue growing in the coming

years. In terms of supply, the United States is currently the largest producer of natural gas, followed by Russia and Iran. Other major producers include Qatar, Canada, China, and Norway. The IEA reports that global natural gas production reached a record high in 2019, with an estimated 3.9 trillion cubic meters produced worldwide [25].

Regarding supply share by country, Russia is currently the largest exporter of natural gas, followed by Qatar and Norway. The United States has also become a major exporter in recent years due to its shale gas boom. In terms of importers, Japan is currently the largest importer of liquefied natural gas, followed by China and South Korea [22].

Natural gas import and export situation varies greatly depending on regional demand and supply dynamics. For example, Europe has become increasingly dependent on LNG imports due to declining domestic production and reduced pipeline imports from Russia. Meanwhile, Asia has seen a surge in LNG demand as countries such as China and India seek to transition away from coal-fired power generation. While there are some regional variations in supply and demand dynamics for natural gas, it remains an essential source of energy for many countries around the world [12,25].

The global natural gas supply has been on a steady rise, according to the International Energy Agency (IEA). Over the past decade, global natural gas consumption has increased, which is expected to continue in the coming years. The United States is currently the largest producer of natural gas, followed by Russia and Iran. Other significant producers include Qatar, Canada, China, and Norway [22]. In 2019, global natural gas production reached a record high of approximately 3.9 trillion cubic meters [10].

When examining the supply share of natural gas by country, Russia takes the lead as the largest exporter, followed by Qatar and Norway. The United States has also become a major exporter in recent years due to the shale gas boom. On the import side, Japan is the largest importer of liquefied natural gas (LNG), followed by China and South Korea. Natural gas import and export situation varies depending on regional demand and supply dynamics. For example, Europe has increasingly relied on LNG imports due to declining domestic production and reduced pipeline imports from Russia. Conversely, Asia has experienced a surge in LNG demand as countries such as China and India aim to shift away from coal-fired power generation [9].

In light of the growing demand for natural gas in emerging countries and its impact on global supply, the security of gas supply in Europe has become a paramount concern. The rapid growth of gas demand in emerging countries, such as China and India, presents a challenge to the stability of gas supply in Europe [11] as these countries increase their use of natural gas, competition for limited supplies of LNG intensifies, leading to potential price volatility and supply chain disruptions.

This competition for LNG supplies can significantly affect Europe's gas market, mainly if Asian countries are willing to pay higher prices for LNG. European buyers may struggle to secure sufficient supplies at affordable prices, resulting in shortages and price spikes that adversely impact European consumers and businesses. To address these challenges, European countries are taking steps to enhance the security of their gas supplies. These measures include investments in new infrastructure such as pipelines and LNG terminals and diversification of supply sources. Some European countries are exploring new sources of natural gas, such as shale gas, or renewable gases, such as biogas, to ensure access to reliable and affordable supplies in the present and future [17].

While the rapid growth of gas demand in emerging countries poses challenges to the stability of gas supply in Europe, proactive measures can help mitigate these risks. By investing in infrastructure and diversifying supply sources, European countries can ensure access to reliable and affordable natural gas supplies [11]. Moreover, integrating the development of the gas market into long-term plans for achieving carbon neutrality is crucial. This involves aligning natural gas infrastructure investments with long-term emissions reduction goals, exploring technologies like renewable gases and carbon capture and storage, and implementing supportive policies and regulations. By integrating the gas

market's development into carbon neutrality efforts, countries can contribute to a more sustainable future in the face of climate change.

5. Europe's Increased LNG Imports and Flexibility

Europe's increased LNG imports as a critical factor in the global LNG market. In 2022, Europe boosted its LNG imports by 60% to more than 100 million tons, offsetting the decline in Russian pipeline gas shipments caused by the Ukraine crisis. This increase in LNG imports allowed Europe to maintain its energy security and meet its energy needs, despite the supply disruptions caused by the crisis [20].

According to a report by the International Energy Agency (IEA), Europe's reliance on LNG imports is set to continue in the coming years. The IEA notes that Europe's gas demand is expected to grow by 1.5% per year until 2025, with LNG imports expected to account for a significant portion of this growth [31]. This highlights the growing importance of LNG as a core energy supply for Europe as the region seeks to meet its energy security needs.

Europe's increased LNG imports have also highlighted the flexibility of the LNG industry. The ability to redirect LNG shipments to different markets in response to changing demand has allowed the industry to respond quickly to the supply disruptions caused by the Ukraine crisis. This flexibility has been a key factor in enabling Europe to maintain its energy security and meet its energy needs, despite the supply disruptions caused by the crisis.

Europe's increased LNG imports have been a key factor in the global LNG market. The ability to redirect LNG shipments to different needs in response to changing demand has allowed the industry to respond quickly to supply disruptions and maintain energy security. With LNG expected to become a core energy supply for Europe in the coming years, the flexibility of the LNG industry will be increasingly important for meeting the region's energy needs [20].

The situation of oversupply in the LNG market is not new, and it has been observed before, as in 2019, when global supplies collided with weak demand, leading to a global LNG glut. However, the COVID-19 pandemic aggravated this oversupply situation, and by the summer of 2020, global LNG markets were in severe oversupply [27]. This oversupply led to lower-than-expected prices, which have been a significant concern for LNG exporters, and it is expected that global LNG prices will remain structurally elevated for several years due to weak supply growth and robust demand [15,27].

In this context, LNG exporters will have to focus on developing strategies to cope with the volatile market conditions and remain competitive. One strategy is to optimize their liquefaction processes and logistics to lower production costs and increase profit margins. Moreover, LNG exporters could expand their customer base beyond traditional markets, such as Japan and South Korea, to other emerging markets, such as China and India, which are expected to drive global LNG demand [27].

Evidence suggests that LNG exporters should prioritize diversifying their portfolio by investing in alternative energy sources, particularly renewables, due to their growing cost competitiveness and potential for stable long-term revenue [15]. This approach provides a strategic advantage by mitigating the risks associated with overreliance on the LNG trade alone. Furthermore, exploring partnerships and collaborations with key industry stakeholders, including shipping companies, can offer benefits, such as economies of scale and operational cost reduction, enhancing LNG exports' overall competitiveness and sustainability. In conclusion, the LNG market's volatility and oversupply have led to falling prices and lower profits for exporters, making it essential for them to develop robust strategies to cope with these conditions. By optimizing their liquefaction processes, diversifying their portfolio, and exploring new partnerships, LNG exporters can remain competitive in a rapidly changing market and secure their long-term profitability.

LNG industry stakeholders must monitor the global supply and demand dynamics in light of the current market conditions and adapt accordingly. With the expected growth in LNG demand in emerging markets and uncertainties in Europe, market participants must be flexible and agile in their decision-making. The ability to respond quickly to changing

market conditions and identify new growth opportunities will be critical to ensuring the industry's long-term success.

6. Global Supply and Demand Dynamics

The global gas and LNG markets have been in a state of constant evolution over the past few years. The industry has witnessed significant changes in supply and demand dynamics, driven by various factors, including economic growth, changes in energy policies, and technological advancements. The International Energy Agency (IEA) has projected that global natural gas consumption will continue to increase, driven mainly by Asian economies, including China, India, and Southeast Asia, which are expected to account for nearly half of global gas consumption by 2040 [4].

Europe has become a significant importer of LNG over the past few years, driven by the decline in domestic production, the decommissioning of nuclear and coal-fired power plants, and increasing demand for cleaner energy sources. In contrast, Asia, particularly China, has also emerged as a major LNG importer, driven by its efforts to reduce its reliance on coal and improve air quality. As a result of this intense competition, LNG prices have remained high, leading to concerns over affordability and energy security. The LNG supply-demand dynamics are expected to point towards a structural change in the market, shifting from long-term contracts to spot and short-term contracts, which will give buyers more flexibility in responding to changing market conditions [32].

To summarize, the global gas and LNG markets are forecasted to undergo further evolution, which will drive several factors, including alterations in energy policies, advancements in technology, and global economic growth. The changing market dynamics are expected to usher in a structural transformation, highlighting the industry's need to adopt more flexible contract structures to meet evolving buyer requirements and ensure long-term sustainability. As a result, market participants must remain vigilant and proactive in adapting to the changing market conditions and remain competitive [33].

According to the International Energy Agency (IEA), global natural gas demand is expected to increase by 1.2% per year until 2025, driven primarily by Asian economies, particularly China and India. However, the rate of growth is expected to slow after 2025 due to increasing competition from renewable energy sources and a push toward decarbonization. On the supply side, the IEA projects that global natural gas production will increase by 1.6% per year until 2025, with the majority of the growth coming from the United States, Russia, and the Middle East.

The global LNG market is forecasted to witness a 45% increase in liquefaction capacity between 2020 and 2026, primarily owing to the initiation of fresh projects in countries such as the United States, Russia, Australia, and Qatar. Nevertheless, in the short to medium term, the demand for LNG is expected to surpass its supply, with Asia and Europe vying for a restricted new supply [21]. IEA predicts that prices will persistently remain high owing to the continued growth in demand and the challenges faced in augmenting the supply [4].

The competition for limited new supply is particularly acute in Europe, where demand for natural gas and LNG has surged due to the closure of coal-fired power plants and the retirement of nuclear reactors. However, Europe is facing increasing competition for LNG from Asia, particularly China, which is expected to overtake Japan as the world's largest LNG importer by the mid-2020s. This competition for limited new supply is expected to keep prices high and create opportunities for LNG traders and exporters to capture value [22].

The global gas and LNG markets are expected to face structural changes that will shape the industry for decades to come. Despite the expected growth in the short term, there are concerns about increasing competition from renewable energy sources and a push toward decarbonization. The competition for limited new supply is particularly acute in Europe due to the closure of coal-fired power plants and the retirement of nuclear reactors, leading to a surge in demand for natural gas and LNG [4].

However, Europe is also facing increasing competition for LNG from Asia, particularly China, expected to overtake Japan as the world's largest LNG importer by the mid-2020s. This competition for limited new supply is expected to maintain high prices and create opportunities for LNG traders and exporters to capture value. To navigate the highly competitive and dynamic global gas and LNG markets, industry stakeholders must develop robust strategies that address the challenges of oversupply, market volatility, and changing demand patterns [20].

7. Impacts of Decarbonization Policies on the LNG Gas Market

The global energy landscape is experiencing a significant shift towards decarbonization as countries strive to mitigate climate change and transition to cleaner and more sustainable energy sources. As part of this transition, major gas buyers worldwide are implementing decarbonization policies that aim to reduce greenhouse gas emissions and promote the use of renewable energy sources. These policies have the potential to significantly impact the liquefied natural gas market, which has traditionally been a key player in meeting global energy demand. This article explores the potential effects of decarbonization policies on the LNG gas market and discusses their implications for industry stakeholders [18].

Adopting decarbonization policies by major gas buyers, such as China, India, Japan, South Korea, and Taiwan, can change their energy composition and reduce dependence on LNG as a primary energy source. This shift can be attributed to increased investments in renewable energy technologies, energy efficiency measures, and the electrification of various sectors. Consequently, there may be a decline in the demand for LNG, leading to significant implications for LNG exporters. They may witness a decrease in their market share and the need to explore alternative markets or adapt their business strategies accordingly [30].

Decarbonization policies commonly encompass measures such as carbon pricing, emissions regulations, and subsidies for renewable energy. These initiatives tend to raise the costs associated with the utilization of fossil fuels, including LNG, making it less economically attractive compared to cleaner alternatives. Consequently, LNG prices may become less competitive, potentially impacting the profitability of LNG projects and investments. Moreover, the inherent volatility of the LNG market may be further intensified by changing market conditions and policy interventions.

The influence of decarbonization policies extends to investment decisions within the LNG sector. With governments and investors prioritizing low-carbon technologies and infrastructure, capital could be reallocated away from LNG projects towards renewable energy initiatives. This shift poses challenges for developing LNG infrastructure, including the construction of liquefaction plants, storage facilities, and shipping infrastructure. Furthermore, existing LNG facilities may need to adapt to accommodate the evolving energy landscape by integrating technologies, such as carbon capture and storage (CCS), or exploring opportunities for renewable gas production [30].

Despite the challenges posed by decarbonization policies, the LNG gas market can still perform a significant role in the ongoing energy transition. LNG can serve as a transitional fuel in sectors where low-carbon alternatives are not yet readily accessible, such as heavy-duty transportation and industries with high-temperature heat requirements. Furthermore, advancements in LNG technologies, such as small-scale LNG and LNG bunkering for maritime applications, offer niche market opportunities and regional energy solutions [18].

Implementing decarbonization efforts is expected to decrease the overall demand for natural gas, including LNG. As countries embrace renewable energy technologies and adopt energy efficiency measures, the reliance on fossil fuel-based energy sources, including LNG, will likely diminish. Decarbonization policies may drive the substitution of LNG with lower-carbon alternatives. The increasing reliance on renewable energy sources, such as wind and solar power, and cleaner fuels, such as hydrogen, may further impact the demand for LNG in the market [19].

Furthermore, decarbonization policies can influence the regulatory framework governing natural gas usage. Governments may introduce stricter emission standards, carbon

pricing mechanisms, or other regulations targeting greenhouse gas emissions associated with natural gas production, transportation, and consumption. These regulations can increase costs and operational challenges for LNG producers and buyers, potentially affecting the competitiveness and attractiveness of LNG as an energy source [24].

Moreover, decarbonization policies can stimulate investments in alternative energy infrastructure, such as renewable energy generation and energy storage. This investment would enhance the availability and affordability of clean energy options, further influencing the demand for LNG. The transformative impact of decarbonization policies by major gas buyers on the LNG gas market will largely depend on the specific policies and actions undertaken by individual countries and regions to reduce their carbon footprint and transition to cleaner energy systems.

8. Future Outlook and Investment Needs

The global LNG trade has been increasing in recent years. In 2021, global LNG trade reached 381 million tons, and it is expected to rise further to 397 million tons in 2022 [9]. This trend is driven by the increasing demand for natural gas, particularly in the heavy-duty transport sector, as countries seek to reduce their carbon emissions. The use of LNG in heavy-duty transport has increased significantly, particularly in Europe and Asia, where decarbonization is strongly focused.

Several new LNG export terminals are under construction in the US, which will significantly increase the country's LNG export capacity. Qatar is also expanding its LNG production capacity, planning to increase its annual LNG production from 77 million tons to 126 million tons by 2027. However, despite the expected increase in supply, there is a need for further investment to avoid a potential supply-demand gap. Demand for natural gas continues to grow in emerging markets, such as China and India [15]. Significant investment is required in new liquefaction plants, LNG carriers, and infrastructure, such as storage tanks and regasification facilities to meet this demand.

China is the world's largest LNG importer, accounting for 20% of global LNG imports in 2020 (International Gas Union, 2021). The country has been expanding its LNG import infrastructure and is increasingly using short-term and spot LNG contracts to meet its growing demand for natural gas [15].

China has also been increasing its role in the global LNG market by increasing its LNG imports and investing in LNG infrastructure. China became the world's second-largest LNG importer in 2021, surpassing South Korea, and it is expected to continue to be a major driver of global LNG demand growth [32]. Moreover, China has been increasingly using LNG to improve the flexibility of its natural gas supply, as LNG can be transported and stored more easily than pipeline gas. This flexibility is important for China, which has experienced supply disruptions due to pipeline gas disputes with Russia [34].

Most new LNG supply is expected to come from the US and Qatar, but further investment is required to avoid a potential supply-demand gap. China is also increasingly important in the global LNG market, providing more flexibility to LNG suppliers. In terms of investment needs, the growth of global LNG demand and the retirement of older liquefaction plants will require significant investment in new liquefaction capacity. However, this investment may face challenges, including the need for long-term contracts to secure financing and the increasing competition from renewables in the power sector [26].

9. Conclusions

This article highlights the current state of the global gas and LNG markets, emphasising the supply and demand dynamics, pricing trends, and investment needs. The global gas and LNG markets have experienced significant growth over the past few years, driven by the increasing demand from Asia and the adoption of gas in heavy-duty transport. However, this growth has also led to a supply-demand gap and a decline in prices in certain markets, emphasizing the need for further investment in new supply infrastructure.

Looking towards the future, the majority of new LNG supply until 2030 is expected to come from the US and Qatar, with China performing an increasingly important role in providing flexibility to the global LNG market. While the future of the global gas and LNG markets is one of continued growth and evolution, it is essential to note that the market will face challenges, such as supply-demand imbalances and competition from renewable energy sources. The increasing role of China in the global LNG market is providing more flexibility to the market and contributing to its growth, but there are still challenges with existing facilities and slow supply growth.

The future of LNG demand growth is still being determined due to various factors, such as concerns over fuel supply security and affordability, a decrease in gas consumption in Europe, and the investment in cost-competitive energy alternatives over the next few years. To avoid a supply-demand gap, further investment in infrastructure and technology will be necessary. The global LNG market will continue to evolve and face challenges, and market participants must stay informed and adapt to changing market conditions. Thus, strategic investment and collaboration between industry stakeholders must ensure a sustainable and stable market.

The Paris Agreement, adopted in 2015, aims to tackle climate change and limit global temperature rise. This research evaluates the impact of the agreement's climate policies on natural gas demand and the long-term gas market. The agreement promotes greenhouse gas mitigation, renewable energy promotion, and energy efficiency improvements. While emphasizing the transition to low-carbon sources, it recognizes natural gas as a cleaner alternative. However, the long-term implications on gas demand depend on policy implementation, technological advancements, and renewable energy competitiveness. Market dynamics may shift as carbon neutrality gains importance, requiring the gas industry to adapt strategies and invest in carbon capture and storage technologies. The Paris Agreement marks a significant milestone, and the gas industry should anticipate and align with evolving market dynamics and sustainability goals.

The global natural gas supply has experienced steady growth, with increasing consumption projected for the future. The United States, Russia, and Iran are the largest producers, while Russia, Qatar, and Norway lead as exporters. Japan, China, and South Korea import liquefied natural gas. However, the rapid growth of gas demand in emerging countries, such as China and India, challenges the security of gas supply in Europe, where competition for limited LNG supplies can lead to price volatility and supply disruptions. To address these challenges, European countries invest in infrastructure and diversify supply sources. Additionally, integrating the development of the gas market into long-term carbon neutrality plans is essential, involving reducing reliance on fossil fuels and exploring cleaner energy alternatives. By adopting innovative solutions, policies, and technologies, we can create a more sustainable future that balances the demand for natural gas with the imperative of mitigating climate change.

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References

1. Kruyt, B.; van Vuuren, D.P.; de Vries, H.J. The security of energy supply and climate policy: Assessing interactions. *Energy Policy* **2010**, *38*, 3408–3420.
2. Christopoulos, A.G.; Kalantonis, P.; Katsampoxakis, I.; Vergos, K. COVID-19 and the Energy Price Volatility. *Energies* **2021**, *14*, 6496. [CrossRef]
3. Santos Da Silva, S.R.; Miralles-Wilhelm, F.; Muñoz-Castillo, R.; Clarke, L.E.; Braun, C.J.; Delgado, A.; Edmonds, J.A.; Hejazi, M.; Horing, J.; Horowitz, R.; et al. The Paris pledges and the energy-water-land nexus in Latin America: Exploring implications of greenhouse gas emission reductions. *PLoS ONE* **2019**, *14*, e0215013. [CrossRef] [PubMed]
4. International Energy Agency. Global Energy Review 2020. 2020. Available online: https://www.iea.org/reports/global-energy-review-2020 (accessed on 12 March 2023).
5. International Energy Agency. Gas 2021: Analysis and Forecasts to 2026. 2021. Available online: https://iea.blob.core.windows.net/assets/1fa45234-bac5-4d89-a532-768960f99d07/Oil_2021-PDF.pdf (accessed on 12 March 2023).
6. Lindberg, M.B. The EU emissions trading system and renewable energy policies: Friends or foes in the European policy mix? *Politics Gov.* **2019**, *7*, 105–123. [CrossRef]
7. Shell. LNG Outlook 2023: Market Report. 2023. Available online: https://www.shell.com/energy-and-innovation/natural-gas/liquefied-natural-gas-lng/lng-outlook-2023.html (accessed on 22 May 2023).
8. International Energy Agency. Gas 2022: Analysis and Forecast to 2027. 2022. Available online: https://iea.blob.core.windows.net/assets/64c27e00-c6cb-48f1-a8f0-082054e3ece6/Renewables2022.pdf (accessed on 12 March 2023).
9. Shell. Shell's LNG Outlook 2021. 2021. Available online: https://www.shell.com/promos/lng-outlook-2021/_jcr_content.stream/1614251291068/66d4057bade4db4c685d4b8e774c6ed43f6dbb98/shell-lng-outlook-2021-report.pdf (accessed on 12 May 2023).
10. Shaikh, F.; Ji, Q.; Fan, Y. Assessing the stability of the LNG supply in the Asia Pacific region. *J. Nat. Gas Sci. Eng.* **2016**, *34*, 376–386. [CrossRef]
11. Merkulov, V.I.; Skripnuk, D.F.; Kulik, S.V. Analysis of world LNG production capacity. In *IOP Conference Series: Earth and Environmental Science*; IOP Publishing: Bristol, UK, 2020; Volume 539, p. 012057.
12. Vivoda, V. LNG import diversification in Asia. *Energy Strategy Rev.* **2014**, *2*, 289–297. [CrossRef]
13. Fulwood, M.; Henderson, J.; Gomes, I.; Lambert, M.; Sharples, J. *Emerging Asia LNG Demand (No. 162)*; OIES Paper: NG; Oxford Institute for Energy Studies: Oxford, UK, 2020.
14. Chernyaev, M.; Kudriakov, D.F. Russian LNG in the global market: Features, prospects and barriers. *Sci. J. Econ. Syst.* **2020**, *13*. Available online: https://www.elibrary.ru/item.asp?id=44411256 (accessed on 20 May 2023).
15. McKinsey & Company. Global Gas Outlook to 2050. 2021. Available online: https://www.mckinsey.com/industries/oil-and-gas/our-insights/global-gas-outlook-to-2050 (accessed on 3 May 2023).
16. Chen, R.; Qi, P.; Hang, X.; Li, C. Evolution laws and new trends of global LNG pricing and their implications. *Nat. Gas Ind. B* **2021**, *8*, 475–483. [CrossRef]
17. Wood Mackenzie. Global LNG Short-Term Outlook: H1 2022. 2022. Available online: https://www.woodmac.com/research/products/oil-markets-short-term-outlook/global-lng-short-term-outlook-h1-2022/ (accessed on 11 June 2023).
18. Vivoda, V. LNG import diversification and energy security in Asia. *Energy Policy* **2019**, *129*, 967–974. [CrossRef]
19. Najm, S.; Matsumoto, K.I. Does renewable energy substitute LNG international trade in the energy transition? *Energy Econ.* **2020**, *92*, 104964. [CrossRef]
20. Zou, Q.; Yi, C.; Wang, K.; Yin, X.; Zhang, Y. Global LNG market: Supply-demand and economic analysis. In *IOP Conference Series: Earth and Environmental Science*; IOP Publishing: Bristol, UK, 2022; Volume 983, p. 012051.
21. Liu, Y.; Shi, X.; Laurenceson, J. Dynamics of Australia's LNG export performance: A modified constant market shares analysis. *Energy Econ.* **2020**, *89*, 104808. [CrossRef]
22. Norman, J. The emergence of China as an LNG super user. *APPEA J.* **2019**, *59*, 667–670. [CrossRef]
23. Anderson, K.; Broderick, J. *Natural Gas and Climate Change*; University of Manchester: Manchester, UK, 2017.
24. Bresciani, G.; Heiligtag, S.; Lambert, P.; Rogers, M. The Future of Liquefied Natural Gas: Opportunities for Growth. McKinsey & Company. 2020. Available online: https://www.mckinsey.com/industries/oil-and-gas/our-insights/the-future-of-liquefied-natural-gas-opportunities-for-growth (accessed on 23 January 2022).
25. International Energy Agency. Global Gas Security Review 2021. 2021. Available online: https://www.iea.org/reports/global-gas-security-review-2021 (accessed on 5 March 2023).
26. Deloitte. 2022 LNG Market Outlook: A New Era for Liquefied Natural Gas. *Deloitte Insights.* 2022. Available online: https://www2.deloitte.com/us/en/insights/industry/oil-and-gas/lng-market-outlook.html (accessed on 10 May 2023).

27. IEEFA. Global LNG Outlook 2023-27. 2023. Available online: https://ieefa.org/resources/global-lng-outlook-2023-27 (accessed on 20 May 2023).
28. International Energy Agency. Gas Market Report Q1-2023. 2023. Available online: https://www.iea.org/reports/gas-market-report-q1-2023 (accessed on 12 March 2023).
29. International Energy Agency. Natural Gas Markets Remain Tight as Uncertainty Persists around Chinese LNG Demand and Further Supply Cuts by Russia. 17 May 2023. Available online: https://www.iea.org/news/natural-gas-markets-remain-tight-as-uncertainty-persists-around-chinese-lng-demand-and-further-supply-cuts-by-russia (accessed on 12 March 2023).
30. International Gas Union. IGU World LNG Report 2022. 2022. Available online: https://www.igu.org/publications/igu-world-lng-report-2022/ (accessed on 12 June 2023).
31. International Energy Agency. Energy Security. 2021. Available online: https://www.iea.org/topics/energy-security (accessed on 2 March 2023).
32. Wood Mackenzie. Gas Markets: Global Gas Markets Long-Term Outlook H1 2020 Base Case. 2020. Available online: https://www.woodmac.com/reports/gas-markets-global-gas-markets-long-term-outlook-h1-2020-base-case-432091/ (accessed on 12 March 2023).
33. Kotagodahetti, R.; Hewage, K.; Perera, P.; Sadiq, R. Technology and policy options for decarbonizing the natural gas industry: A critical review. *Gas Sci. Eng.* **2023**, *114*, 204981. [CrossRef]
34. Global Energy Monitor. Gas Run Aground 2022. 2022. Available online: https://globalenergymonitor.org/wp-content/uploads/2022/03/Gas-Run-Aground-2022.pdf (accessed on 2 April 2023).