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Study on the Impact of the European Energy Crisis on LNG Shipping

Tonglin Ding

Study on the Impact of the European Energy Crisis on LNG Shipping

DING, TONGLIN

A dissertation submitted to the World Maritime University in partial fulfilment of the requirements for the award of the degree of Master of Science in Maritime Affairs

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Declaration

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

(Signature): DING, TONGLIN

(Date): 19 May 2023

Supervised by: ZHANG, RENPING

Supervisor's affiliation: Dalian Maritime University

Acknowledgement

Whatever your name is, a whole new journey will begin in your name at MSEM.

And I, being over 40 years old and a captain of a ship, have finally put my name firmly on the line with WMU & DMU. I would like to thank all the teachers who have helped me in the MSEM program.

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Abstract

Title of Dissertation: Study on the Impact of the European Energy Crisis on LNG Shipping

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In the dissertation, the author reviews the literature from the perspective of the LNG shipping market, collates the current status of the LNG supply chain and analyses the changes that have occurred in the supply and demand pattern of LNG shipping. The author attempts to identify the specific impact of the European energy crisis on LNG shipping from various authoritative reports on the LNG supply chain industry, as well as from his own and relevant experts' understanding of shipping expertise, in a timeline perspective including short and medium to long term. As well as geopolitical perspectives including on superpowers such as the US and China. The research employs a sophisticated methodology to study the development of the global LNG shipping market from a macro qualitative perspective, making full use of a variety of authoritative data analysis reports. Contributions to the dissertation include an understanding of the dynamics of the LNG shipping market in China, accelerate the establishment and improvement of the LNG supply chain construction in order to achieve adaptation to changes in supply and demand, cope with risk transmission and ensure the normal development of China's LNG supply chain industry. The final part of this dissertation is dedicated to presenting recommendations to address the short, medium and long term to cover future responses to the energy crisis in order to mitigate the impact on LNG shipping due to unforeseen events such as geopolitics.

Key words: Energy crisis，LNG shipping，Gas prices，LNG supply & demand

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BP	British Petroleum
CI	Composite Index
CII	Carbon Intensity Index
COP27	The 27th Conference of the Parties
COVID	Crown Virus
EC	European Commission
EEXI	Energy Efficiency Existing Ship Index
EIA	Energy Information Administration
ENA	Ecological Network Analysis
EU	European
FSRU	Floating Storage and Regasification Unit
GDP	Gross Domestic Product
GHG	Greenhouse Gas
IMO	International Maritime Organization
IGU	International Gas Union
IEA	International Energy Agency
LNG	Liquefied Natural Gas
MEPC	Marine Environment Protection Committee
PEEST	Political Economic Environmental Social Technological
R&D	Research and Development
US	United States
UNCTAD	United Nations Conference on Trade and Development

UN	United Nation

Chapter 1. Introduction

1.1 Background of topic selection

Liquefied natural gas (LNG) is an important clean energy source with the advantages of high efficiency, environmental protection and safety, and has been widely used in power generation, transportation, industry and other fields. Energy plays an important role in world relations, and LNG in particular will be an energy consuming resource that industry will rely on for a long time to come.

Russia and the EU have maintained a high level of interdependence in the energy sector, establishing mutual energy dialogue and cooperation mechanisms and several transport pipelines for energy. However, since the conflict between Russia and Ukraine in early 2022, the explosion and leakage of the Nord Stream-2 pipeline in the sea off Denmark on September 26, 2022, has exacerbated the turmoil in the international LNG market (Sever, 2022). This incident triggered a fierce game between the party using energy as a bargaining chip, completely breaking the original energy ties between Russia and Europe. Against the background of the Russia-Ukraine conflict, the energy ties between Russia and Europe are unlikely to be restored in the future, and the EU has proposed to “reinvigorate Europe” and further accelerate the energy transition away from dependence on Russian fossil energy. The EU is actively seeking to replace Russia's pipeline gas and renewable energy resources with the aim of rebalancing the European gas supply chain (Shell

plc, 2022).

Driven by the global energy transition and carbon neutrality targets, the LNG industry has a promising future. As a key transition fuel, natural gas will grow by +0.2% per year to 2050, with a peak from 2030 onwards. The use of natural gas for transport remains largely concentrated in maritime transport (Abouarghoub & Haider, 2019). The curbs on emissions will come first from transport. Natural gas and decarbonized, low/zero-carbon gases would initiatives work together to drive the global energy transition. Potential global CO_2 storage capacity by region (**Figure 1**).

Figure 1

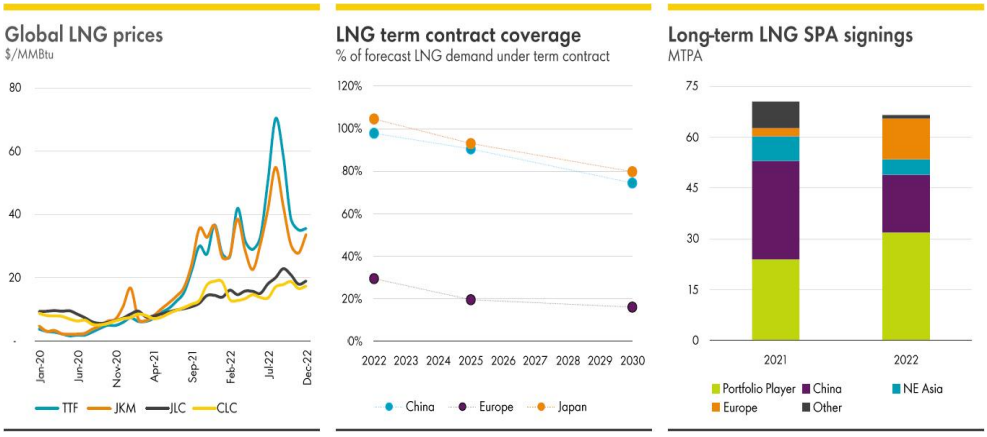
Potential Global CO_2 Storage Capacity by Region

Note. From *Global Gas Report (p,27),* by International Gas Union (IGU), 2022, IGU (https://www.igu.org/resources/global-gas-report-2022/). Copyright 2022 by IGU and Snam.

However, the European energy crisis has had an impact on the development of the LNG industry. The European energy crisis refers to the shortage of energy supply and high prices in Europe due to the high energy dependence of European countries and the lack of development of renewable energy sources. The underlying fundamentals leading to natural gas are shown through the price fluctuations (**Figure 2**).

Figure 2

Global LNG Prices. LNG term Contract Coverage. Long-term LNG SPA Signings



Note. From *Shell LNG Outlook (p,27),* by Shell plc, 2023, Shell plc (https://www.shell.com/energy-and-innovation/natural-gas/liquefied-natural-gas-lng/lng-outlook-2023.htm). CC BY.

This has created certain challenges to the development of LNG industry, such as the increase of LNG price, the decrease of demand and the increase of competition (Alizadeh et al, 2019).

Therefore, an in-depth study on the impact of European energy crisis on LNG shipping will help to understand the development trend of LNG industry, find coping strategies, and provide reference and support for the sustainable development of LNG shipping.

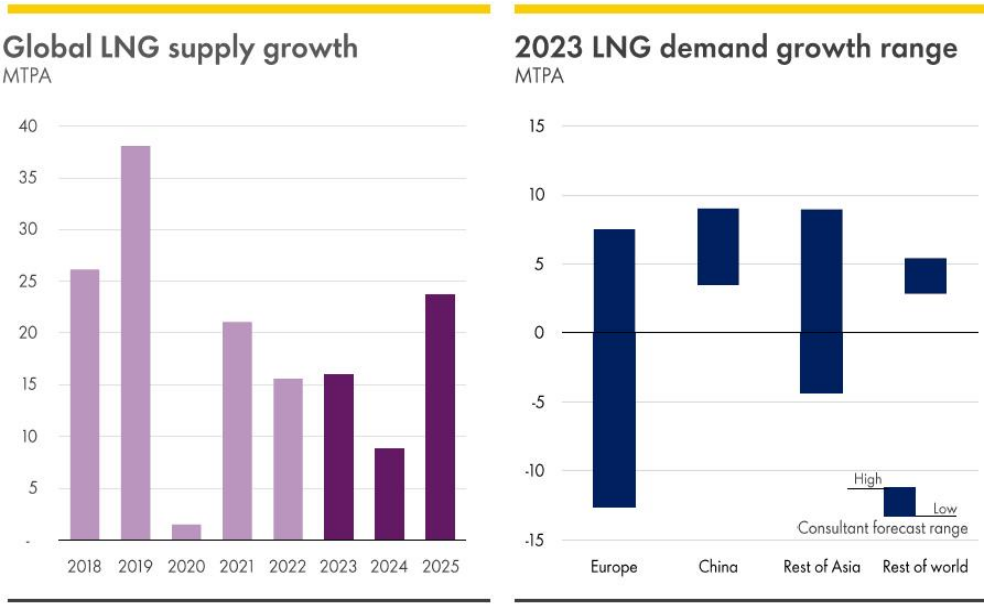
1.2 Purpose and significance of the study

The purpose of this dissertation is to examine the changing landscape of LNG shipping in the context of the turbulent international LNG shipping supply chain, building a response to China's LNG shipping supply chain and optimizing future import strategies in the context of the European energy crisis. Unlike previous studies, this thesis examines the security of LNG imports from the perspective of the global LNG shipping supply chain.

Competing between Europe and China for limited volumes of LNG (**Figure 3**). China should be prepared to cope with the tightening supply and soaring prices in the global LNG market in the short term, and in the medium to long term, LNG shipping companies should grasp the international LNG shipping trade planning, accelerate the establishment and improvement of LNG shipping related work, adapt to the changes brought about by the energy crisis and respond effectively to the risk transmission in the international shipping market for LNG.

Figure 3

Global LNG supply growth. 2023 LNG demand growth range



Note. From *Shell LNG Outlook (p,22),* by Shell plc, 2023, Shell plc (https://www.shell.com/energy-and-innovation/natural-gas/liquefied-natural-gas-lng/lng-outlook-2023.htm). CC BY.

The study of the impact of the European energy crisis on LNG transportation has the following implications:

(1) To understand the transport situation and development trend of the LNG industry in the context of the European energy crisis, and to provide reference for decision-making by relevant stakeholders such as governments and enterprises.

(2) To explore the impact of the European energy crisis on the LNG industry, providing ideas and suggestions for the LNG industry to cope with the crisis from the

political, economic, environmental, social and technological perspectives respectively.

(3) Analyze the relationship between the LNG market and the European energy crisis, analyze the changes in LNG shipping supply and demand, and explore in depth the impact mechanisms between the two.

(4) To discuss the impact of the EU energy crisis on LNG shipping and to promote the sustainable development of the LNG industry.

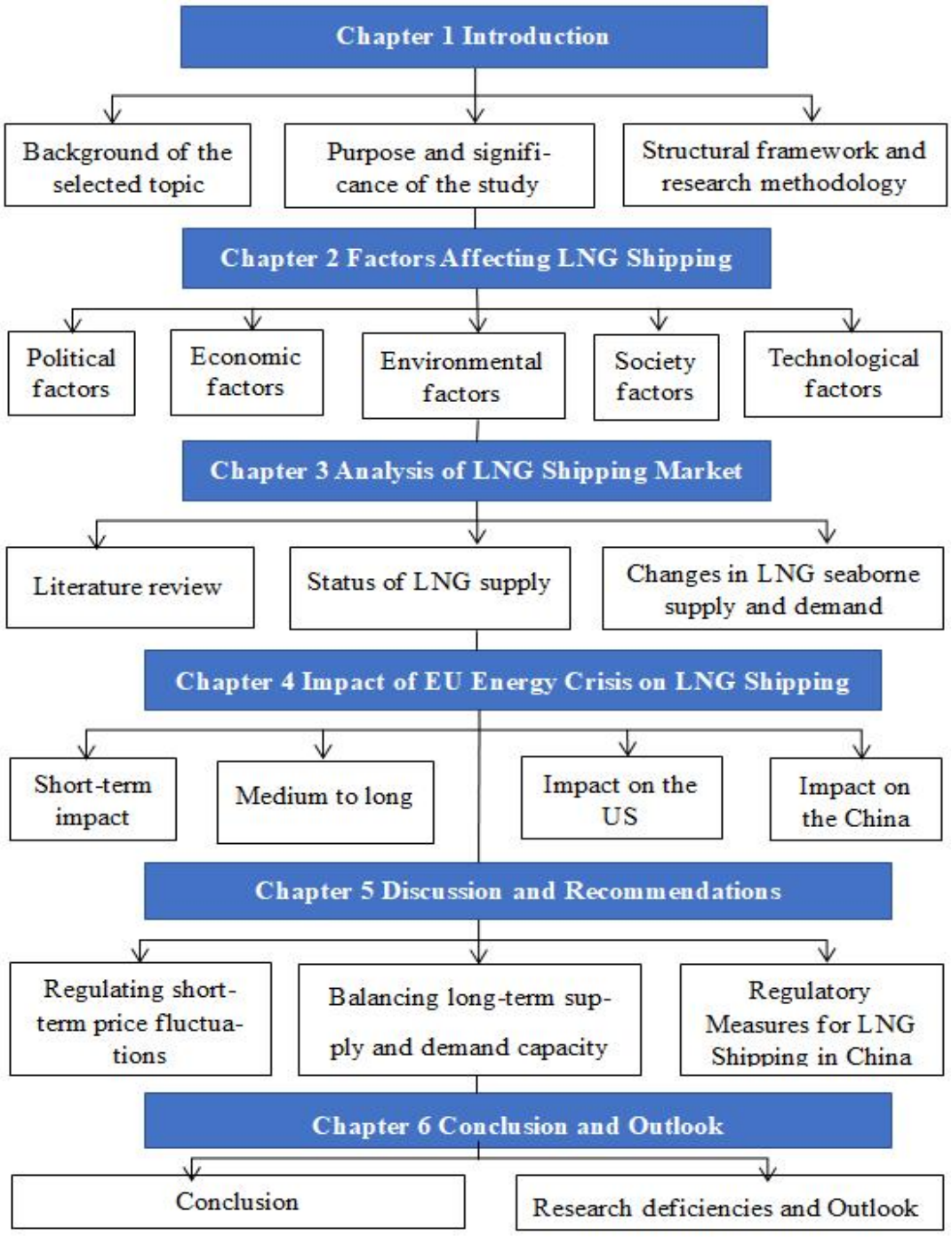
(5) To expand research in the field of LNG shipping and provide suggestions for academic research in related fields in China.

1.3 Structural framework and research methodology of this dissertation

1.3.1 Structural framework (Figure 4)

Figure 4

Structural Framework



1.3.2 Research program

Approaches to studying the impact of the European energy crisis on LNG shipping could include the following:

(1) PEEST analysis

This thesis mainly introduces the macro environment background of LNG shipping through PEEST analysis, where P is political, analyzing the impact of European energy crisis on the policies and regulations of LNG transport enterprises, E is economic, analyzing the impact of European energy crisis on LNG price, demand and supply, E is environmental, analyzing the increasing requirements for environmental protection in Europe and the need for LNG transport enterprises to consider more environmental protection under the energy crisis, S is social, analyzing the impact of European energy crisis on the social image and reputation of LNG transport enterprises, T is technological, analyzing the need for LNG transport enterprises to pay more attention to technological innovation and upgrading.

These five PEEST contextual factors were used to analyze the overall LNG shipping market and the impact of the European energy crisis, to provide an overview and summary of the LNG industry, LNG shipping, and the European energy crisis, to understand the current state of relevant research and problems, and to derive the situation and future outlook for LNG shipping. In conducting the PEEST analysis, a variety of authoritative sources are used and a large number of relevant research materials are available as proof to achieve an in-depth understanding and recommendations for the industry under analysis.

(2) Data analysis

Data is collected from a range of LNG shipping markets, LNG prices, LNG demand and LNG transport, and these authoritative reports are statistically analyzed to reveal

the impact of the European energy crisis on LNG transport, and to identify the opportunities and challenges it faces during the crisis.

The combined application of the above research methods can provide a comprehensive understanding of the impact of the European energy crisis on LNG shipping, identify the problems and challenges involved, and propose corresponding conclusions and recommendations.

Chapter 2 Factors Affecting LNG Shipping

2.1 Political Factors

Political factors refer to political risks, the possibility of conflicts between countries, or changes in political relations between one country and other countries, which may have some impact on the reliability of LNG maritime transportation. Historically, Europe and Russia have a long history of energy cooperation and Europe has been dependent on Russian energy supplies, but the conflict between Russia and Ukraine became a turning point and the strongest "energy ties" between Russia and Europe were gradually severed (Shadurskiy, 2022).

Turmoil in energy markets has increased since two Nord Stream pipeline leaks. Now, the Nord Stream pipeline leak has completely cut off Europe's access to natural gas from Russia through the Nord Stream pipeline. The complete cessation of Russian gas supplies to Europe will cut off all outside pipelines to Western Europe, leaving

only the Turk Stream pipeline, which carries Russian gas to Turkey and some Southern European countries. This puts Europe in a difficult position to cope with the cold winter of 2022. The political environment in LNG seller countries has a significant impact on LNG buyer countries and companies and determines the security of transportation in the LNG energy supply chain (Li & Zhou, 2021) . Whereas the political environment is the basis for maintaining political stability, investments in energy projects such as LNG require a stable political environment where operators, investors and consumers are protected from each other in terms of policy (IGU, 2022).

The adjustment of energy policies in European countries also affects the development of LNG transport enterprises. Against the background of the economic downturn in Europe, some countries have started to adopt trade protectionist measures, raising tariffs and taxes on imported LNG and increasing the operating costs of LNG transport enterprises. As European countries promote green energy development and reduce dependence on fossil fuels, LNG transport enterprises need to strengthen investment and Research and Development (R&D) in environmental protection and energy transition, which brings negative impact to LNG transport enterprises.

The Russia-Ukraine conflict has exacerbated supply constraints in the international LNG market, leading to a period of historically high LNG shipping prices, which will reshape the global market flow of international gas, prompting accelerated transatlantic exports of US gas to Europe and the transfer of Russian gas to Asia, slowing Asian demand for international LNG resources and changing the international LNG trade and shipping landscape.

2.2 Economic Factors

Experiencing a new coronavirus outbreak, while the Ukraine crisis exacerbates geopolitical risks, providing further justification for globalized economic setbacks (Han & Chen, 2021). 2022 sees the fragile recovery lose momentum and the war in Ukraine brings new disruptions, leading to higher global inflation and cost of living. The COVID-19 wave, meanwhile, further disrupts supply chains, particularly in China, where a zero-COVID policy remains in place until December 2022.

The world now faces the prospect of recession and stagflation, and for 2022, the United Nations Conference on Trade and Development (UNCTAD) reports a slowdown in maritime trade growth to 1.4%, with the war in Ukraine leading to a shift in trade patterns and partners. Forecasting the impact of seaborne trade on GDP (**Table 1**). Pandemics and wars exacerbate geopolitical risks, providing further justification for global economic setbacks (UNCTAD, 2022).

Table 1

Forecasting the Impact of Seaborne Trade on GDP, 2022-2027

International maritime trade developments forecasts,2022–2027 (annual percentage change)			
	Annual Growth	Years	Seaborne trade flows
UNCTAD	1.4	2022	Total seaborne trade
	1.4	2023	
	2.2	2024	
	2.3	2025	
	2.3	2026	
	2.2	2027	
	1.2	2022	Containerized

UNCTAD	1.9	2023	trade
	3.0	2024	
	3.1	2025	
	2.9	2026	
	3.8	2027	
Clarksons Research	0.9	2022	Total seaborne trade
	2.2	2023	
	-0.1	2022	Containerized trade
	2.4	2023	

Note. Adapted from *International maritime trade (p,21),* by UNCTAD, 2022, UNCTAD (https://unctad.org/system/files/official-document/rmt2022_en.pdf). CC BY.

In the Review of Maritime Transport 2022, UNCTAD calls for increased investment in the maritime supply chain. Economies and shipping supply chains are inextricably linked and interact as a community. The report notes that over the past two years, the world economy has been burdened by disruptions in the global maritime supply chain due to the continued spread of the COVID-19 pandemic and economic sanctions related to the Russian-Ukrainian conflict. Since the Russia-Ukraine conflict, there has been a crisis in the LNG shipping supply chain, with an expanding gas transportation market leading to a surge in freight rates, port congestion and a mismatch between supply and demand for LNG shipping logistics capacity. Freight rate spikes have led to soaring consumer prices, while supply chain disruptions can lead to a host of economic problems such as layoffs and food security (OECD, 2022).

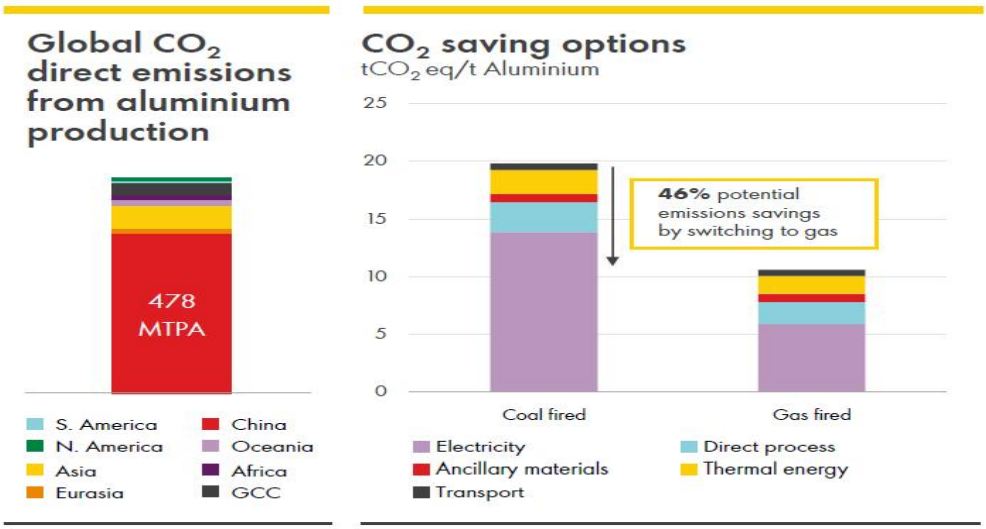
The economic weakness in European countries has led to a decline in demand for LNG and LNG transporters are facing a market with insufficient demand. Rising gas prices in Europe have also increased the operating costs of LNG carriers, and the profitability of LNG carriers has been affected to some extent.

2.3 Environmental factors

First the shipping industry is working together to combat climate change. on November 20, 2022, the 27th Conference of the Parties (COP27) to the United Nations Framework Convention on Climate Change (UNFCCC) was held. Based on the COP26, some 120 countries set a target to reduce greenhouse gas (GHG) emissions to net zero by 2050 (United Nations, 2022). Against the backdrop of a growing global energy crisis, record high GHG concentrations, and frequent extreme weather events, the 27th UN Climate Change Conference is proposed to take action on a number of key issues based on the outcomes of the 26th Conference. In the case of electricity sources, for example, the use of natural gas to decarbonize is effective in reducing carbon emissions (**Figure 5**). Natural gas can play an important part in the energy transition.

Figure 5

Global CO_2 Direct Emissions and Saving Options



Note. From *Shell LNG Outlook (p,9),* by Shell plc, 2022, Shell plc (https://www.shell.com/energy-and-innovation/natural-gas/liquefied-natural-gas-lng/lng-outlook-2022.html). CC BY.

Second, in accordance with the International Maritime Organization (IMO) for greenhouse gas emission reduction targets, the Marine Environment Protection Committee completed an amendment to MARPOL Annex VI to monitor emissions reductions from ships (IMO, 2021). The measure, which requires ships to adopt effective means to improve energy efficiency, calculate their Energy Efficiency Existing Ship Index (EEXI), and determine their annual operational Carbon Intensity Index (CII) and CII rating, comes into effect on January 1, 2023. In line with IMO's initial strategy for greenhouse gas emission reductions, IMO is revising its initial strategy with the aim of achieving net zero emissions and carbon neutrality targets by 2050.

Based on the above environmental objectives, in addition to seeking energy alternatives, the application of artificial intelligence has great potential for reducing

emissions in the maritime sector (Munim et al, 2020a). LNG as an ecologically important over-energy alternative, is a favorable alternative to traditional ship fuels in the energy substitution, the energy transformation involving shipping fuel pollution, and is expected to have a combined annual growth rate of 5.8% between 2020 and 2027 (Grand View Research, 2019).The low-carbon nature of natural gas serves as an effective tool for decarbonization and is also gradually industrialized as a fuel for energy transition, with the advantages of being intermittent like other renewable energy sources. The European Commission has considered considering gas-burning power plants as green energy generators. This indicates that the LNG transport market will remain at a peak in the coming years. Demand and supply of LNG bunkering is increasing rapidly as greenhouse gas concentrations continue to reach record levels and the global fleet shifts fuel to LNG to drive decarbonization (IGU, 2022).

With the increasing importance of environmental protection in European countries, LNG transport companies need to pay more attention to issues such as ship emissions, port environment, and other aspects, increasing environmental pressure on LNG carriers, using liquefied natural gas that ships can limit and reduce their carbon footprint (Panayides, 2020). European countries' efforts in energy transition also have an impact on the environmental impact of LNG carriers. While promoting the development of green energy, European countries are also developing new energy technologies and searching for renewable alternative energy sources, which could potentially threaten LNG carriers.

2.4 Social factors

The social impact of the European energy crisis on LNG transportation is manifested in two main ways. First, LNG transporters need to pay more attention to people's reactions to the energy crisis issues. During the European energy crisis, public attention to energy issues has been increasing to avoid negative impacts due to social opinion. The recent years have highlighted the dynamics of challenges across the supply chain, as well as when it comes to security threats. Operate in the global supply chain need to be flexible enough to establish, secondly, during the European energy crisis, LNG transport companies need to pay more attention to social image and reputation, reducing the negative impact of the energy crisis (TT, 2022).

The current crisis will eventually pass, but from a longer time dimension, the crisis may re-emerge for various reasons and cause a series of social problems. The crisis is caused by natural gas, so solving the dependence on natural gas is the root cause of ending the crisis, so the first task is to accelerate the energy transition in Europe and speed up the development of new energy alternatives.

The crisis has affected Germany to extend the use of nuclear power plants and restart coal-fired power generation in order to replace natural gas generation, which is contrary to the vision of decarbonization of environmental protection goals in the short term within the last 3 years, but this energy crisis in Germany has not only not slowed down the speed of Germany's energy transition, but also prompted Germany to greatly accelerate the development of renewable energy sources such as wind and light energy to replace the natural gas supplied by Russia. Accelerating the energy transition will not only reduce carbon dioxide emissions, but also get rid of the threat of imported energy supply security, which has also become a stronger public consensus in Germany, but the actual energy transformation is not short-term, so the EU member states should ensure the establishment of LNG fuel supply infrastructure

in the main ports by 2025 (Rob, 2022). Russia wants to use the gas supply cut-off to force the people of the EU countries to put pressure on their governments and force the EU to press Ukraine to reach a compromise with Russia, which will easily highlight social conflicts. The German government, a representative of Europe, insists on the speedy completion of the LNG receiving terminal, which will purchase a large amount of spot LNG from the international market, without signing new long-term supply agreements with any country, because with the rapid growth of renewable energy sources in Germany, mainly wind power, the amount of imported LNG in Germany will decline rapidly. In such a social game to find a way out (Wang & Chen, 2022).

2.5 Technological factors

During the European energy crisis, LNG transporters need to focus more on technological innovation and upgrading in order to improve the efficiency and reliability of LNG transport technology and thus improve their competitiveness. LNG is a processed material with unstable properties, and LNG itself possesses corrosive properties that eventually cause leakage of LNG equipment (Zhang et al, 2021). It is more prone to accidents during storage and transportation, which can cause irreparable damage and, in serious cases, threaten the lives of the workers involved.

The conditions of LNG storage and transportation are high and need to maintain low temperature and high pressure. In the actual storage and transportation process, it is affected by the way of transportation and the surrounding environment, which in turn affects the storage temperature of LNG. The materials of the equipment used for storage and transportation of LNG are very important, and the materials selected are

not easy to deform at high or low temperatures, and are less affected by the outside world during transportation and cannot produce large temperature changes. Technical safety work in the storage and transportation process is directly related to the safety of LNG storage and transportation. Regular inspections by professionals are needed to obtain the storage status of LNG, and monitoring alarms can provide support for the efficient development of safety management in all segments (Jiang, 2020). Ensuring the safety and reliability of operational processes and preventing leaks and other accidents. The efforts of European countries in developing new energy technologies also have an impact on the technological impact of LNG transportation, and LNG transporters need to pay close attention to the development trends and response strategies of new energy technologies.

In summary, the European energy crisis has had political, economic, environmental, social and technological impacts on LNG shipping, and LNG carriers need to strengthen their investment and research and development in environmental protection and energy transition, and pay more attention to the public's concerns about energy issues.

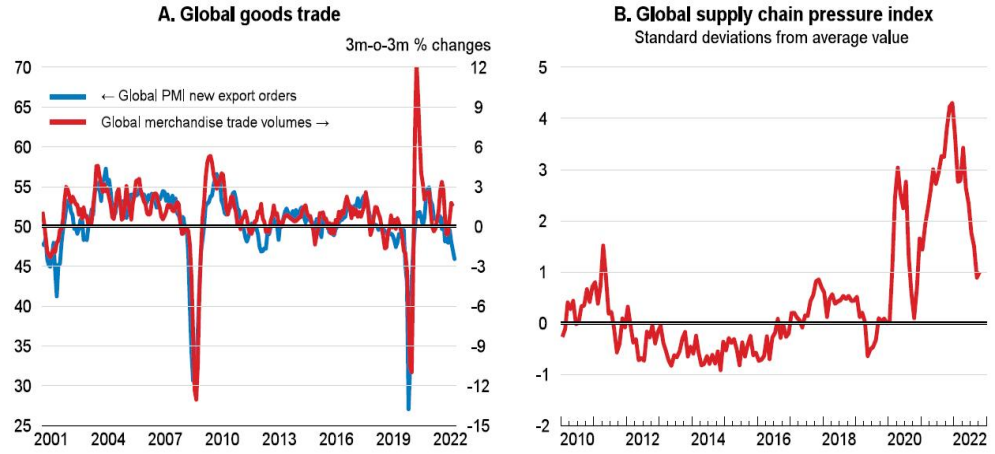
Chapter 3. Analysis of LNG Shipping Market

The slowdown in global economic growth and trends in global supply chains and export orders (**Figure 6**), against a backdrop of ongoing geopolitical conflict, as the European energy crisis continues and the global energy market changes, LNG as a

clean and efficient energy source, is being adopted by more and more countries and regions, and the LNG shipping market is facing new challenges and opportunities.

Figure 6

Global Goods Trade and Supply Chain Pressure Index



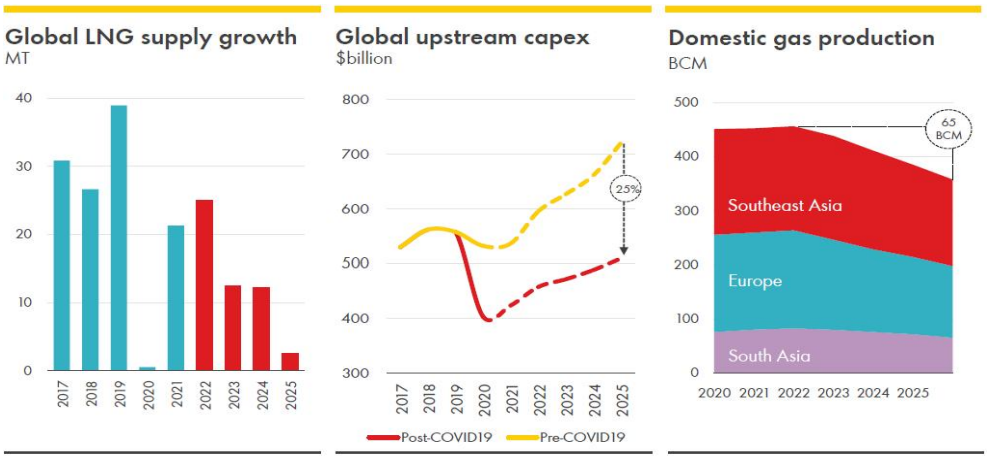
Note. From *OECD economic outlook (p,25),* by OECD, 2022, OECD (https://www.oecd-ilibrary.org/economics/oecd-economic-outlook/volume-2022/issue-2_f6da2159-en). CC BY.

As for April 2022, there are 40 import markets and 19 export markets connected to LNG (IGU, 2022). The strong performance of the LNG shipping market in 2021-2022 has seen a change in supply and demand in the global LNG shipping market (McKinsey & Company, 2022), with rates soaring, LNG capacity supply shortages, new vessel orders breaking record highs, extremely tight floating storage and regasification unit (FSRU) capacity, and rapid expansion of LNG receiving infrastructure, a trend that is expected to continue in 2023. Expectations of a tight

global LNG market from 2021 drive new contract signings (**Figure 7**). This chapter will analyze the current status of the European LNG supply chain and the changes in LNG maritime supply and demand.

Figure 7

Global LNG Supply Growth. Upstream capex. Domestic Gas Production



Note. From *Shell LNG Outlook (p,25),* by Shell plc, 2022, Shell plc (https://www.shell.com/energy-and-innovation/natural-gas/liquefied-natural-gas-lng/lng-outlook-2022.html). CC BY.

3.1 Literature review of related theoretical studies

This section reviews domestic and international literature on LNG supply in terms of factors influencing LNG supply, current situation analysis and forecasting, evaluation and countermeasures.

The maritime supply of LNG belongs to the scope of energy security research, and researchers in many countries have conducted a series of studies and obtained rich research results. The domestic research field is relatively late, but the related scientific work is progressing faster. LNG shipping in the context of the energy crisis involving national energy security studies, security of supply and demand involves various related factors such as PEEST in Chapter 2, for example, price security in economic factors means that natural gas prices are subject to fluctuations in prices and market indices, and then security of use on the demand side means preventing natural gas from causing harm to the environment or people in the process of use. security of LNG maritime supply is ultimately about maintaining a stable national energy supply, involving natural gas production, transportation, consumption and other multi-link processes.

Security of supply of LNG by sea as defined in this paper shall mean effective domestic demand for LNG, responding to large short-term market fluctuations and seeking assurance of stable and reliable supply in the medium to long term to meet long-term security of supply. the steady development of the LNG industry is a matter of importance to countries around the world. This paper reviews the research results in the current situation and forecast of LNG supply, risk evaluation of LNG supply and countermeasures based on the influencing factors of natural gas supply by collecting LNG supply security research from different perspectives in foreign and domestic countries as follows. The impact and role of LNG in energy security is an area of research that addresses all the dilemmas that arise in energy security in terms of security of supply (Zhang & Tan, 2020). The identification of natural gas as a transitional fuel into the decarbonization era, the security of supply of LNG in the short-term energy crisis and the sustainability of the decarbonization energy transition in the long term. The relationship between energy security and LNG

shipping is addressed by discussing the international linkages and examining the geopolitical interactions (Sever, 2022).

As early as more than a decade ago Costantini et al. analyzed the study of Europe's external energy dependence and vulnerability as international energy experts, countries that depend on imported LNG energy are at risk of inadequate or disconnected supply, followed by supply-demand imbalance, which will likely lead to unstable exports due to insufficient demand, in addition to insufficient infrastructure and other influencing factors, proposing that working together with exporting countries. As early as more than a decade ago Heidari and Katircioglu (2013) boundary tests were used to study the impact of natural gas supply prices until 2007, specifying the relationship between consumption and economic growth, concluding that there is a synchronous positive impact of natural gas consumption and national economic growth. Aguilera et al. explore the question of whether the Asia-Pacific gas market is large enough, by analyzing estimates of potential gas consumption in the Asia-Pacific region and using them to project consumption to 2030, examining how it will meet future energy demand, comparing these projections with the current security of gas supply (including local, pipeline, and LNG) in the Asia-Pacific region. Aguilera and Inchauspe (2014). Awadhesh et al. focused on the extraction of natural gas from shale in the U.S. and assessed the evolution and challenges of shale gas production and supply in the U.S. Reasoning about environmental risk factors, shale gas supply in the U.S. will be curbed. Wang and Awadhesh (2014). Shaikh et al. assessed China's natural gas supply security using a system-oriented modeling ecological network analysis (ENA) approach to identify all key components of China's natural gas supply system, and the study showed that domestic natural gas production contributes significantly to China's natural gas supply security system. Shaikh (2016). Pavlovića et al study proposed a

robust composite index (CI) to measure it. The CI includes the following indicators: import dependence index, total domestic demand, and national economy dependence index on natural gas. Alizadeh et al (2019) marked lack of response and deviation from the classics to market crises is associated with changes in view of shipping companies' expectations by studying. Kian, G. L and Michelle, L (2020) according to the findings of our empirical study, diversifying the LNG fleet increases operational effectiveness and profitability.

A rational discussion of China's current natural gas supply security issues is extracted, which summarizes and concludes the current key issues affecting China's natural gas supply security, and finally gives specific measures to improve China's natural gas supply security management system from the perspective of internal and external security respectively. He Runmin et al (2019). A two-way dynamic game model between importing and exporting countries is developed, whose model takes into account both economic interests and natural gas supply security objectives, and analyzes the impact of joint infrastructure construction by natural gas importing and exporting countries on natural gas export prices (Zhang & Zhang, 2021). From the scientific connotation of the new development pattern, Vice Premier Liu He proposes that the key to building a new development pattern of "double cycle" is to realize economic circulation and open up the industrial chain, and the main way to achieve this is to improve the innovation and relevance of the supply system in order to solve various development obstruction problems. Liu He (2020). Economist Justin Yifu Lin believes that the new development pattern is based on China's development stage, internal and external environment, and changing economic and political conditions, and is a strategic choice to promote China's international cooperation and gain international competitive advantage. Justin Yifu Lin (2020). Jiang Xiao Juan et al. studied the relationship and changes of the internal and external circulation in

China's economic development in the past seven decades mainly from the academic theory perspective, and the study proved that the external circulation did play a decisive and driving role in the past, but now with the remarkable changes in various aspects, the shift to the internal circulation is the inevitable reason. Xiao Juan Jiang, Lijun Meng (2021). Cheng Na studies the evolutionary logic of China's foreign trade strategy transformation under the new development pattern and analyzes the possible paths of its future transformation from various aspects, the most important of which lies in acquiring higher quality international trade based on internal circulation. Cheng Na (2021). Based on the new development pattern, the business environment of coastal provinces is studied at four major levels: macroeconomy, government policy support environment, government effectiveness, and infrastructure (Xie & Tian, 2021).

They analyze the ways to build a "double-cycle" new economic development layout under the new situation, including increasing the supply of advanced technology, implementing the strategy of expanding domestic demand, and comprehensively coordinating and improving the layout of new infrastructure. Han Jing, Chen Xi (2021). For a multi-entity game framework of supply security, it is proposed to investigate the availability, accessibility and affordability of the natural gas industry and supply chain. In this framework, a market equilibrium model for depletable resources based on hybrid complementary planning (MCP) is developed for assessing gas supply security in China considering the dynamic depletion of remaining recoverable reserves. Wang and Qiu (2022). Wang Jie et al (2022) conclude that the future academic community should conduct more research on NDCs from an empirical perspective. Qunhui Huang and Hongfu Ni (2022) constructed a new method of decomposing domestic and international circular GDP based on supply-side and demand-side international and domestic circular GDP

based on global value, and completing an empirical analysis using WIOD-related data, and studying the nature of the new development pattern in depth.

In summary, foreign and domestic scholars have conducted in-depth analyses of the current status of natural gas supply security in different countries and regions. Since LNG supply security involves all parts of the supply chain, scholars in various countries have studied the factors influencing LNG supply security from different perspectives and approaches. Studies of the state of security of LNG supply have focused on a comprehensive analysis of the state of supply in the country or in other countries, usually including a summary analysis of resources, import and export volumes, etc. On this basis, the current situation is summarized and policy recommendations are made, and future LNG market prices, consumption and imports are forecasted based on the data studied.

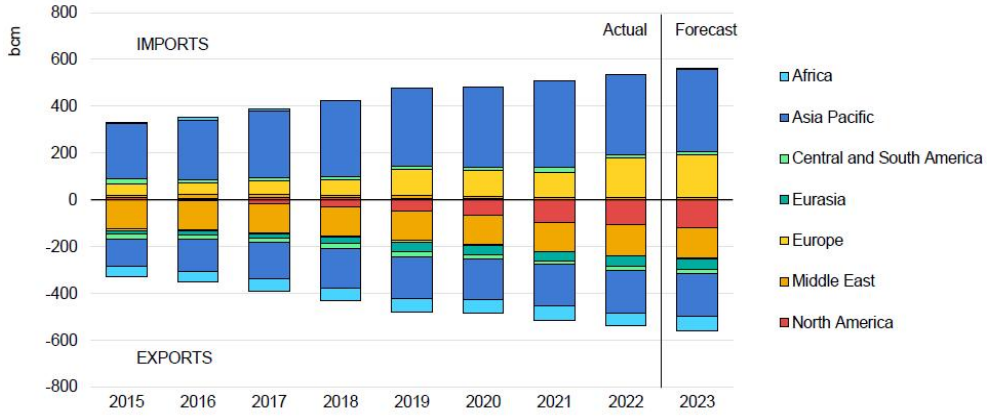
3.2 Status of LNG supply chain

3.2.1 Status of natural gas exporting countries

According to a report by British Petroleum (BP) (BP, 2021), there are 17 major LNG exporters at the end of 2020, and these LNG exporters account for 98.23% of total global LNG exports. The major LNG exporters are Qatar, Australia, the United States, Russia, Malaysia, Nigeria, and Indonesia. Of these, Russia has terminated pipeline gas deliveries to Europe due to the conflict between Russia and Ukraine and the leak in the Nord Stream pipeline. In 2022, Europe drove the growth of LNG imports and North America led the growth of LNG exports, a pattern that is expected to continue in 2023 (**Figure 8**).

Figure 8

LNG Imports and Exports by Region



Note. From *Gas Market Report (p,46),* by IEA, 2023, IEA (https://www.iea.org/reports/gas-market-report-q1-2023). CC BY 4.0.

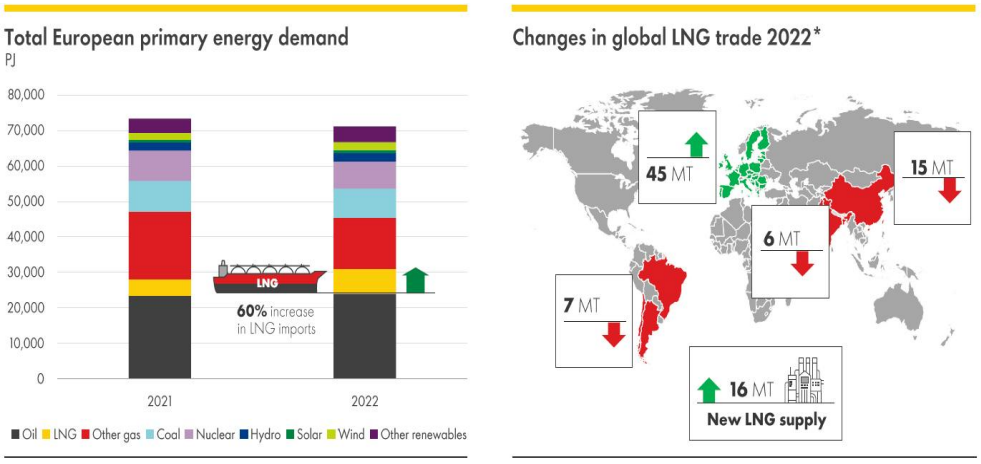
3.2.2 Status of natural gas importing countries

LNG importing countries can be divided into Asian markets, European markets and American markets according to import regions. With the ongoing Russian-Ukrainian conflict having a certain impact on global natural gas supplies, the growing demand for LNG has strengthened the key role of LNG in global energy. Among them, LNG importing countries can be divided by import region into Asian markets, European markets and American markets. As the Russia-Ukraine conflict continues, there is some impact on global gas supplies, the growth in demand for LNG has strengthened the key role of LNG in global energy. This includes a 60% increase in European

LNG imports to replace Russian gas and a reduction in Chinese imports to help balance the global ING market (**Figure 9**).

Figure 9

Global LNG Trade Changes



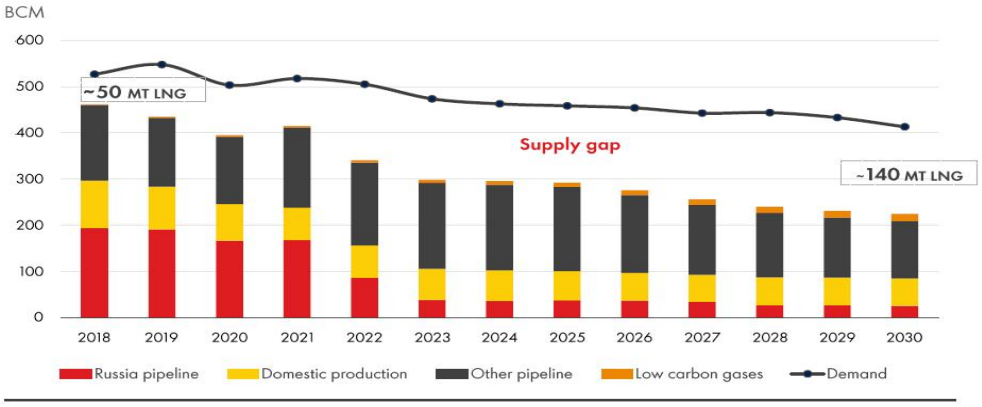
Note. From *Shell LNG Outlook (p,5),* by Shell plc, 2023, Shell plc (https://www.shell.com/energy-and-innovation/natural-gas/liquefied-natural-gas-lng/lng-outlook-2023.html). CC BY.

This is in line with the increased competition for LNG in Asia and the continued growth in global liquefaction capacity. However, despite Asia being a major demand center, LNG shipping replaces pipeline gas as gas is Europe's main source of energy imports and LNG demand in Europe surges due to the emergence of the Russia-Ukraine conflict, resulting in an 11% increase in European LNG trade voyages in 2022 (IGU, 2022). LNG has become a core source of energy supply for Europe. The

loss of Russian pipeline imports has structurally changed the gas market in Europe. (**Figure 10**).

Figure 10

Europe Gas Balance

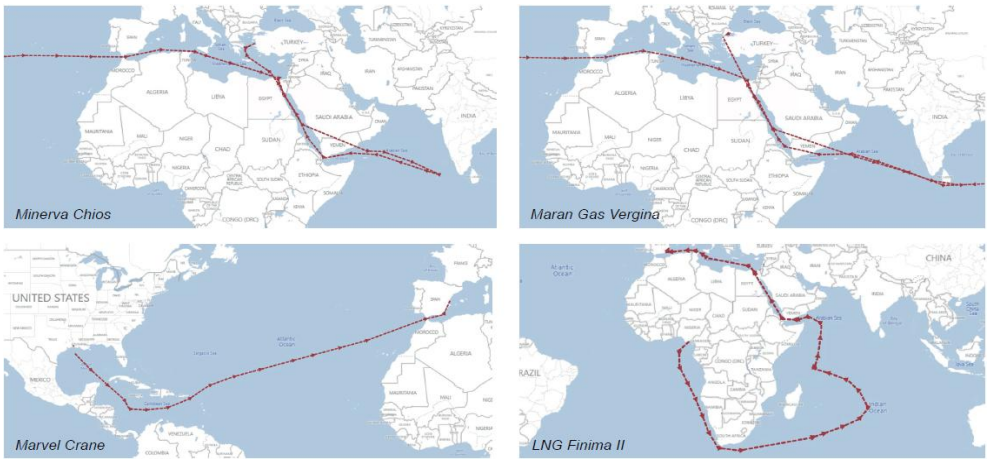


Note. From *Shell LNG Outlook (p,23),* by Shell plc, 2023, Shell plc (https://www.shell.com/energy-and-innovation/natural-gas/liquefied-natural-gas-lng/lng-outlook-2023.html). CC BY.

From the global LNG shipping route map, noted that Asia and Europe are the main import regions from the US. Rerouting of LNG cargo in December 2021 (**Figure 11**)

Figure 11

Rerouting of LNG Cargo

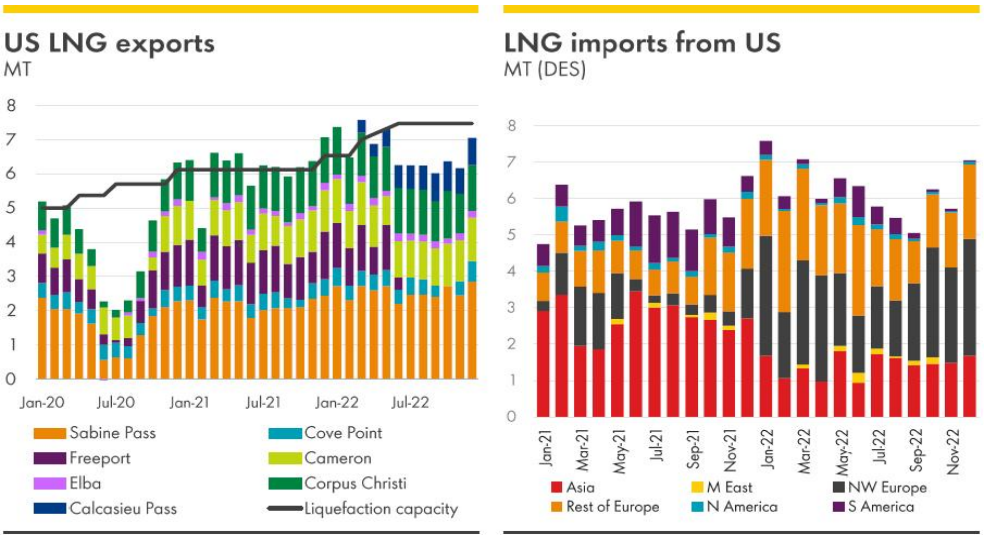


Note. From *Global Gas Report (p,22),* by International Gas Union (IGU), 2022, IGU (https://www.igu.org/resources/global-gas-report-2022/). Copyright 2022 by IGU and Snam.

US LNG exports to Asia will decrease and exports to Europe will increase from 2021 onwards. (**Figure 12**). 2021 total gas consumption in major European countries is 587.5bcm, with 12 countries consuming more than 10bcm, namely Germany, UK, Italy, Turkey, Netherlands, France, Spain, Ukraine, Poland, Belgium, Romania and Hungary, which These 12 countries account for 88% of the total gas consumption in Europe.

Figure 12

US LNG Exports and Imports



Note. From *Shell LNG Outlook (p,9),* by Shell plc, 2023, Shell plc (https://www.shell.com/energy-and-innovation/natural-gas/liquefied-natural-gas-lng/lng-outlook-2023.html). CC BY.

Natural gas consumption in 28 European countries is 501.2 billion cubic meters, of which about 32%, or 160.3 billion cubic meters, comes from Russia. Based on consumption and gas imports from Russia, the gas supply structure in 2021 covers six countries - Germany, the UK, Italy, France, Spain and Poland. Five countries have a high dependence on natural gas of over 76%, except for the UK, whose gas dependence is 57% (JODI, 2022). Specifically, Germany imports all pipeline gas in 2021 and is highly dependent on Russian gas, with Spain and Poland being the least dependent on Russian gas.

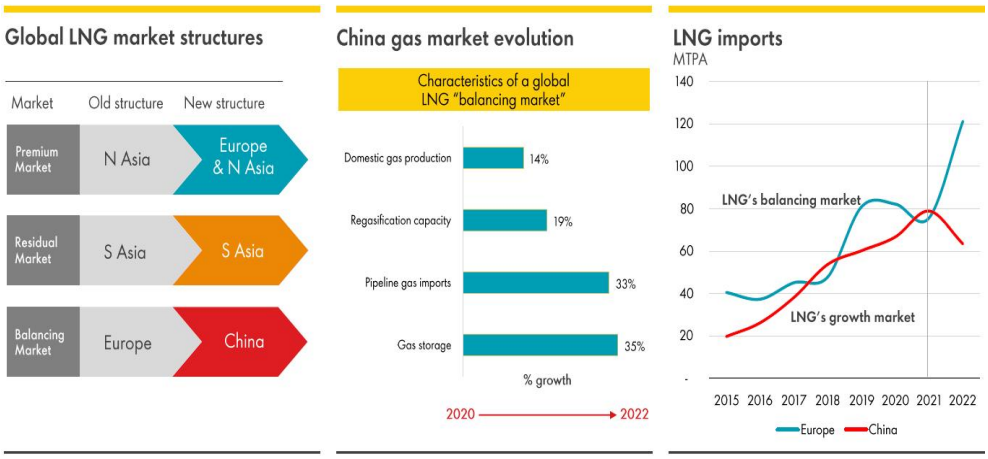
3.2.3 Status of natural gas import in China

China mainly imports LNG from Australia, Qatar, Malaysia, Indonesia and other countries through maritime vessels from the eastern coastal ports, which is a channel. China's LNG imports are flexible, with little participation from private enterprises.

Since the beginning of 2017, China's LNG imports have become the world's second largest LNG importer after Japan (UNCTAD, 2022). This shows the changing role of China in the global LNG market, full flexibility to respond to the market (**Figure 13**).

Figure 13

The Evolving Role of China in the Global LNG Market



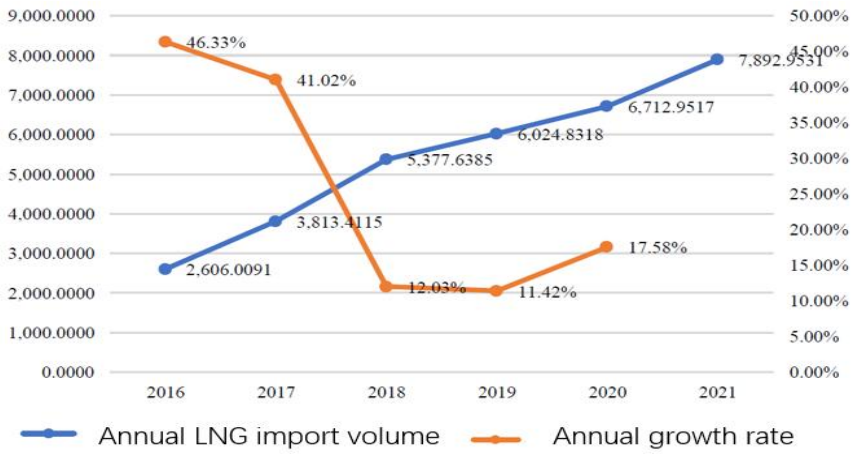
Note. From *Shell LNG Outlook (p,24),* by Shell plc, 2023, Shell plc (https://www.shell.com/energy-and-innovation/natural-gas/liquefied-natural-gas-lng/lng-outlook-2023.html). CC BY.

After largest import growth, China overtakes Japan as largest LNG importer in 2021 (IGU, 2022). By 2021, China's LNG imports reach 108.9 billion cubic meters, up 18.3% year-on-year, and have become a significant part of global LNG imports (Zeng et al., 2022). A new pattern emerges in the share of countries in the global LNG import market.

However, statistics show that China's external dependence on LNG could rise from 43% in 2020 to 62% in 2030 (BP, 2021). This has led to some impact on China's gas supply security, providing a rationale for rebalancing the global LNG import and export trade pattern (Guo et al., 2018). China's imports of LNG from 2016-2021 (**Figure 14**).

Figure 14

Annual Imported LNG Volume in China



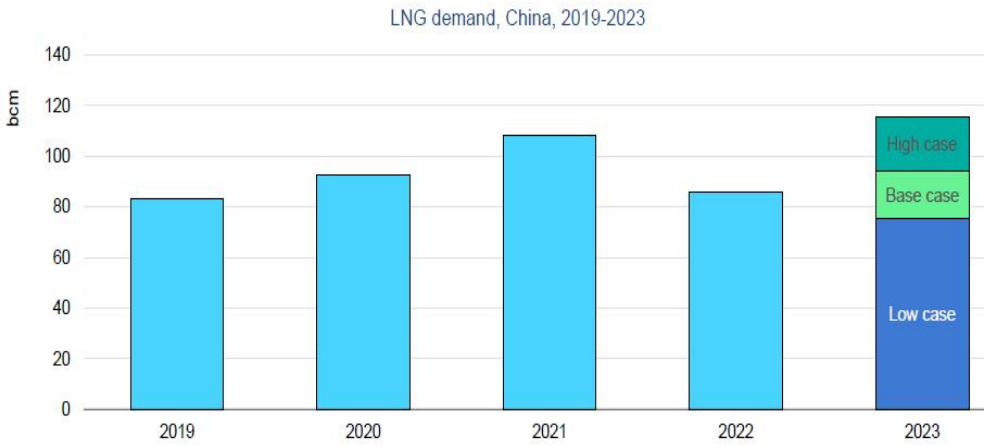
Note. Adapted from *Annual Imported LNG Volume in China,* by *China Customs*, 2021 (http://www.customs.gov.cn/). Copyright 2021 by China Customs

China's pipeline gas import projects usually require long-term agreements due to the high demand for infrastructure. Compared to foreign imports of pipeline gas, LNG imports only require a receiving terminal to be built in the country to meet the goal

of unloading transport vessels. In 2023, China's demand for LNG is forecast to reach 40 billion cubic meters in the global LNG market (**Figure 15**).

Figure 15

LNG Demand, China, 2019-2023



Note. From *Gas Market Report (p,48),* by IEA, 2023, IEA (https://www.iea.org/reports/gas-market-report-q1-2023). CC BY.

The storage and transportation link as LNG shipping generally includes backbone pipeline network, provincial pipeline connection to LNG receiving stations, LNG liquefaction plants, LNG tankers and underground storage depots and other components. The storage and transportation link has the following three main types of business models: LNG receiving stations, LNG liquefaction plants and LNG tankers.

First, LNG receiving stations. Most of the receiving stations are located in the eastern coastal areas of China. LNG receiving stations have the functions of receiving, gasification and peaking, and are the main source of gas in their areas. In the spare time, it can be leased to other LNG traders for direct costs and storage fees. China's receiving stations are rarely rented out during the period when they are not receiving tasks, so the utilization efficiency of the whole LNG receiving station industry in China is low. As LNG receiving stations are the most basic facilities for LNG storage and transportation, China will continue to build receiving stations across the country to enhance storage capabilities (**Table 2**).

Second, LNG liquefaction plants. LNG liquefaction plants can be built in appropriate locations in China, as natural gas fields are far away from the pipeline network, transportation is inconvenient, and pipeline facilities have not yet been laid in the target areas for natural gas end consumption.

Third, LNG tankers. There are three main modes of LNG tanker experience, i.e., completely independent, profitable on freight, and partially integrated with trade and transportation.

Table 2

Expected Commissioning of LNG Receiving Stations in China, 2024-2025

Project	Location	Capacity (million tons/year)	Affiliated companies	Production status
Maoming Yue xi LNG Receiving Station Phase I	Guangdong	300	Xiexin	2024

Jieyang LNG Project	Guangdong	650	PetroChina	2024
Hebei Xin tian Tangshan LNG	Hebei	1200	Hebei Construction Investment	2024
Yangjiang LNG Peaking Storage Phase I	Guangdong	280	Guangdong Electricity	2024
Jiangmen Guanghaiwan LNG Project	Guangdong	300	Jiu feng Energy	2025

Note. Adapted from *Research Institute Public Report,* by CNPC, 2022 (https://www.cnpc.com.cn/cnpc/ndbg/202205/dfacd21e00704c86ad94c6317f755943/files/32925aa9c28043c484e77fb21cbcf936.pdf). CC BY.

3.3 Changes in LNG seaborne supply and demand

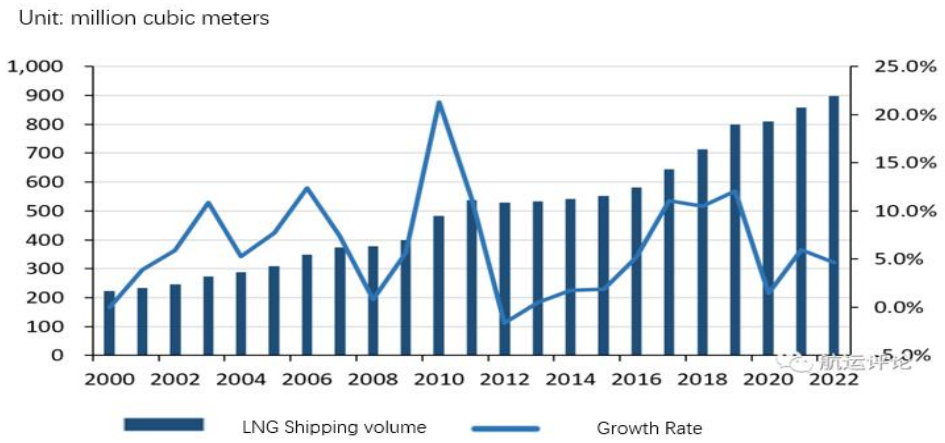
3.3.1 Growth of global LNG seaborne volume

LNG seaborne volume reached 898.8 million m3 in 2022, with a growth rate of 4.65%, maintaining a stable growth overall. There are two main factors: First, greenhouse gas emission reduction policies continue to stimulate demand for natural gas consumption. The entry into force of the Paris Agreement and the proposed climate legislation published by the European Commission (EC) in 2021 aimed at achieving a 55% reduction target by 2030 will give rise to an increase in demand for LNG capacity, due to the fact that natural gas is a major decarbonizing tool and a hydrocarbon identified as being able to be decarbonized on a large scale. It ensures solid power to supplement renewable energy sources and eventually replace coal, prompting LNG to become a more desirable transitional energy source in the short term.

Second, the Russia-Ukraine conflict forced a surge in EU seaborne LNG demand. After the Russia-Ukraine conflict, Europe adopted sanctions against Russia and cut Russian energy imports, plus the destruction of the largest Russian pipeline delivering natural gas to Europe, forcing the transportation of about 167 billion cubic meters of pipeline gas to waterways. The combination of two factors has led to a surge in European LNG demand, with LNG imports by European countries increasing by more than 60% in total to 125 million tons in 2022. The pipeline repair and the restoration of Russian-European trade relations are more difficult in the short term, and the increase in LNG seaborne volumes will continue for quite some time to come (**Figure 16**).

Figure 16

Global Offshore LNG Shipments and Growth Rate



Note. From *LNG offshore market continues to be hot,* by Cuiyun. Z, Jieshu. Z, Weijie. W (Eds), 2023, Shanghai International Shipping Research Centre (https://mp.weixin.qq.com/s/UBc_u6IsWUHoghLs90YuKA). Copyright 2023 by

Cuiyun. Z., Jieshu. Z., Weijie. W.

3.3.2 Huge shocks in LNG vessels' freight rates

It is noteworthy that fleet growth starting in 2021 has seen an unprecedented surge again, and by the end of 2022, the number of global offshore LNG ships has increased to 713 ships, up 29 from the previous year, with fleet capacity of 57,44 million loading tons, up 13.73% compared to the same year. Power demand and power supply determine instant rates and regular rental rates (XIA & CHEN, 2022). Based on the Theory of Balance Price (MARSHALL, 2009).

When the Nord Stream pipeline breaks down, 45% of Europe’s gas pipeline transport will be shifted to sea or search for other alternatives, the demand for offshore LNG transport will increase dramatically, and the LNG ship will be hard to seek, leading to a crazy rental price rise. The shipping price changes can be explained by the return rate and volatility of the stock index, which shows the information spread of the delay (ALIZADEH, 2014).

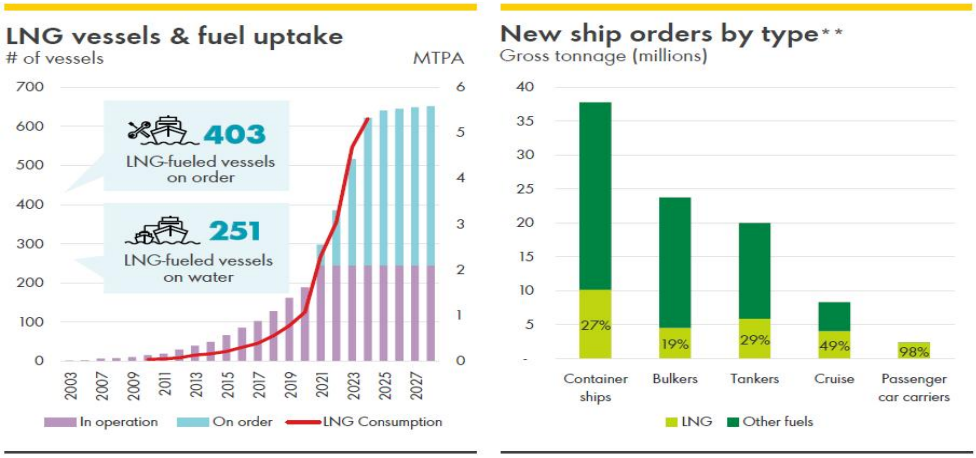
In November 2022, spot charter rates for 160,000cbm LNG vessels reached their highest for the year, rising 118.3% over the same period in 2021 to an average of US$426,300 per day (compared to an annual average of US$131,500). LNG seaborne rates then fell back rapidly to US$163,000 per day by the end of December, due to a short-term contraction in LNG seaborne demand caused by factors such as saturated European stocks. Positive impact of economic policy, uncertainty often harms shipping costs (DROBETZ, 2021).

3.3.3 New LNG vessel orders hit a record high.

The data shows that the order book for new LNG vessels has been maintained at a high level since 2019. New ship orders for 2020, 2021 and 2022 are 54, 85 and 170, respectively, with orders for large LNG vessels of over 140,000cbm at 50, 75 and 165, respectively. 2022 is on fire, with new orders for the year exceeding the sum of orders for the past two years, a record high. Chinese LNG newbuilding ship orders are surging. Before 2022, only Hudong Zhonghua had large LNG production capacity, and as of October 2022, there are Jiangnan Shipbuilding, Dalian Shipbuilding Heavy Industry and China Merchants Industry who have got orders to build large LNG carriers. The next 30% of new ship orders for merchant ships are LNG fuel (**Figure 17**).

Figure 17

LNG Vessels & Fuel Uptake and New Ship Orders by Type

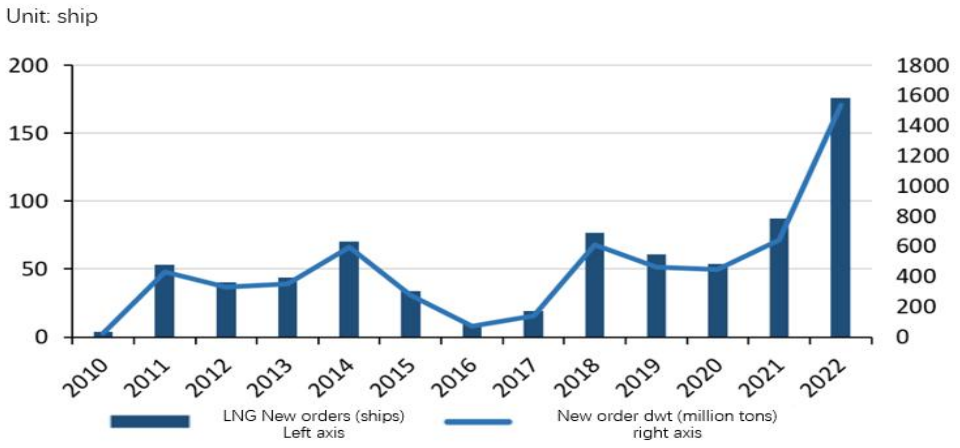


Note. From *Shell LNG Outlook (p,10),* by Shell plc, 2022, Shell plc (https://www.shell.com/energy-and-innovation/natural-gas/liquefied-natural-gas-lng/lng-outlook-2022.html). CC BY.

In 2022, Chinese shipbuilders received orders for 45 LNG carriers, 4.4 million CGT, worth about $9.8 billion, accounting for more than 26.5% globally, with Hudong Zhonghua receiving the largest number of orders 37, and Dalian Shipyard and Jiangnan Shipyard each receiving 6 orders. (**Figure 18**).

Figure 18

Number of LNG Orders and Deadweight Tons



Note. From *LNG offshore market continues to be hot,* by Cuiyun. Z., Jieshu. Z., Weijie. W (Eds), 2023, Shanghai International Shipping Research Centre (https://mp.weixin.qq.com/s/UBc_u6IsWUHoghLs90YuKA). Copyright 2023 by Cuiyun. Z., Jieshu. Z., Weijie. W.

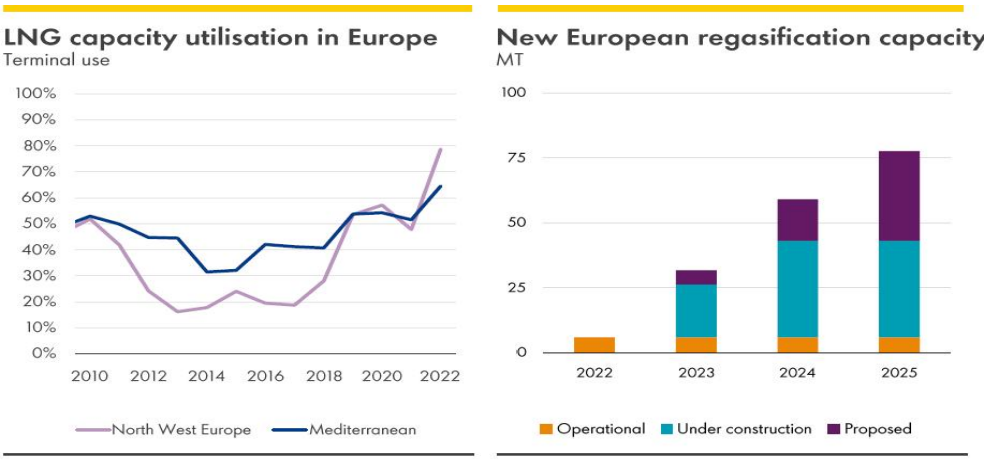
3.3.4 Europe moves away from dependence on pipeline gas to enhanced regasification capacity.

Europe's dependence on Russian pipeline gas resources has been a weak link in Europe's energy security. According to the IEA, in 2019, 40% of Europe's natural gas imports will come from Russia (IEA, 2022). However, because of Europe's overwhelming dependence on Russia, Russia can influence Europe's energy markets by adjusting prices and supplies, which can have political and economic implications. By November 2022, global regasification capacity reached 1010.4 MTPA, an increase of 3.6% year-on-year.

Global LNG receiving terminals are mainly established in the Asian segment, with regasification capacity in Asia reaching 564.6 MTPA, 3.4% increase over the previous year, and only 185.4 MTPA in Europe, an increase of 3.4% year-on-year. European countries accelerated the installation of floating storage and regasification units (FSRU) due to the sharp decline in pipeline gas supply in Europe. Two terminals established within six months to replace LNG imports from Russia (**Figure 19**). Understanding the future role of natural gas is important for investment in infrastructure projects such as liquefied natural gas (LNG) terminals, where security of supply also plays an important role (Scharf et al, 2021).

Figure 19

LNG Capacity Utilisation in Europe and New European Regasification Capacity



Note. From *Shell LNG Outlook (p,15),* by Shell plc, 2023, Shell plc (https://www.shell.com/energy-and-innovation/natural-gas/liquefied-natural-gas-lng/lng-outlook-2023.html). CC BY.

Germany is currently moving forward with five new FSRU projects and two onshore LNG import facility projects, with the first offshore receiving terminal (FSRU) in Wilhelmshaven in the North Sea completed in November 2022, and Greece planning five new FSRU projects with the goal of becoming the gas supply hub for the Southeast Europe region. The Netherlands, Italy, Ireland, France, Finland and Poland are all planning to build FSRU projects, and the large demand for FSRUs has led to tight capacity supply and extended delivery schedules.

In summary, the current state of the supply chain in European LNG consuming countries leads to a consequent change in the configuration of the direction of LNG maritime transport, which in turn has an impact on the LNG shipping market. In this

situation, the LNG shipping market needs to develop appropriate strategies to adapt to the market changes.

Chapter 4. Impact of the EU energy crisis on LNG shipping

The impact on LNG shipping is analyzed according to both time and space according to the comprehensive exploration of the analysis factors of PEEST of political, economic, environmental, social, and technological factors described in Chapter 2, with the timeline analyzed in the first two sections from the short-term impact and the next two sections according to the medium- and long-term impact, as well as the impact on the U.S. and Chinese LNG supply chains from the spatial geopolitical and economic and other factors.

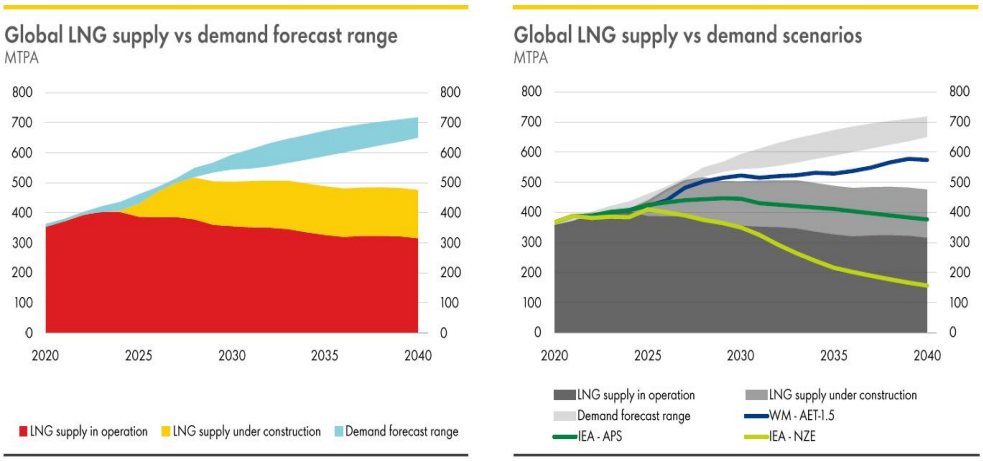
4.1 Short-term effects

February 2022 due to the outbreak of the Russian-Ukrainian conflict, the EU and its member states, together with allies such as the US, the UK and Japan, have imposed ten rounds of sanctions on Russia, including in the energy sector, and there is a serious energy dependence of EU countries on the outside, especially on Russia. Based on the 2020 situation, the EU's external dependence on energy amounts to 58%, with natural gas reaching 83.6%. And natural gas imports from Russia amount to 43% of its energy imports (European Commission, 2022a).

The repeated entanglement of the two sides, superimposed by the factors of hot climate in summer or cold in winter, has created a situation of imbalance between energy supply and demand. On the other hand, the EU has been seeking alternative clean energy and restricting the use of fossil energy for a long time, which has directly or indirectly caused the restriction and shortage of energy supply in Europe, causing significant volatility in natural gas prices, which has a series of impact and influence on the European economy. In the short term, the impact of this energy crisis on the European economy is more obvious, high inflation is estimated to last until 2023, and the European economy is likely to grow at a low rate in 2023, which will further conduct the impact on the LNG shipping market. Supply and demand forecasts (**Figure 20**)

Figure 20

Global LNG Supply vs Demand Forecast range and Scenarios



Note. From *Shell LNG Outlook (p,28),* by Shell plc, 2023, Shell plc (https://www.shell.com/energy-and-innovation/natural-gas/liquefied-natural-gas-

lng/lng-outlook-2023.html). CC BY.

4.1.1 The European economy

(1). Soaring inflation

The energy crisis has exacerbated supply chain disruptions and thus pushed up inflation, causing inflation to soar in the EU and the euro area. Overview of the World Economic Outlook projections for 2021-2023 (**Table 3**)

Table 3

Overview of the World Economic Outlook Projections

			Projections
	2021	2022	2023
World Output	6.1	3.6	3.6
Advanced Economies	5.2	3.3	2.4
United States	5.7	3.7	2.3
Euro Area	5.3	2.8	2.3
Emerging Market and Developing Economies	6.8	3.8	4.4
Emerging and Developing Asia	7.3	5.4	5.6
China	8.1	4.4	5.1

Note. Adapted from *World economic outlook (p,9),* by International Monetary Fund (IMF) staff estimates, 2022, IMF (https://www.imf.org/en/Publications/WEO/Issues/2022/10/11/world-economic-outlook-october-2022). CC BY.

At one point in the year to October 2022, EU inflation rose to 11.5% on an annualized basis (European Commission. 2022b). Eurozone inflation, in particular, was nearly three times as high in that month as it was a year earlier, the highest since records began in 1997 (IMF, 2022). Real GDP and consumer prices in the European economy (**Table 4**)

Table 4

Real GDP and Consumer Prices in the European Economy

	Real GDP			Consumer Prices			Current Account Balance		
			Projections			Projections			Projections
	2021	2022	2023	2021	2022	2023	2021	2022	2023
Europe	5.9	1.1	1.9	4.9	12.6	7.5	3.0	2.0	2.0
Advanced Europe	5.5	3.0	2.2	2.6	5.5	2.7	3.2	1.8	2.1
Euro Area4,	5.3	2.8	2.3	2.6	5.3	2.3	2.4	1.8	2.2

Note. Adapted from *World economic outlook (p,42),* by International Monetary Fund (IMF) staff estimates, 2022, IMF (https://www.imf.org/en/Publications/WEO/Issues/2022/10/11/world-economic-outlook-october-2022). CC BY.

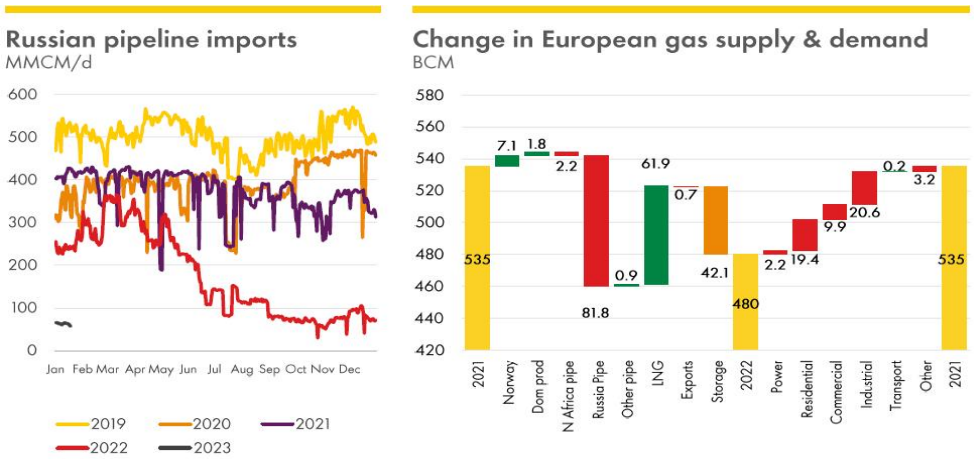
In Germany, inflation has even reached a 70-year high. Among them, rising energy prices are undoubtedly the main driver. in October 2022, among the factors driving inflation in the eurozone, energy contributed 4.44 percentage points and food 2.74 percentage points, with the annual inflation rate of energy reaching 41.5%, far exceeding that of food, which is in second place at 13.1% (European Commission. 2022d).

(2). Rising gas and electricity prices

The decline in Russian gas supplies almost matched Europe's demand, thus upsetting the original balance of supply and demand and leading to a spike in electricity prices. (**Figure 21**)

Figure 21

Russian Pipeline Imports and Change in European Gas Supply & Demand



Note. From *Shell LNG Outlook (p,7),* by Shell plc, 2023, Shell plc (https://www.shell.com/energy-and-innovation/natural-gas/liquefied-natural-gas-

lng/lng-outlook-2023.html). CC BY.

The Russia-Ukraine crisis has brought about an increase in gas and electricity prices to Europe, which, together with food prices, has pushed up the cost of livelihoods. Although the governments of relevant member states have taken measures such as imposing taxes or price limits on energy companies to level out the price of electricity for redistribution, there is no doubt that rising energy prices still have a huge impact on all types of households, especially low-income households. Taking electricity prices as an example, monthly electricity prices in Germany, France, Italy and the UK are 3.8 times (August), 4.4 times (August), 2.2 times (July) and 3 times (September) higher in the highest month of the first 11 months of 2022 compared to January 2022 (TRADING ECNOMICS, 2022) . In the second quarter of 2022, household consumption growth was weak in the EU and the euro area, with average real household consumption growth at the same 0.6%.

On November 9, 2022, the European Commission organized a roundtable exclusively for energy policy makers, energy suppliers, and consumers to discuss how to create additional funds to protect consumers, households, and businesses in the face of high energy prices, and to redistribute windfall profits from energy companies to consumers.

(3). Business operating costs soared

Previously suffering from the impact of the new coronavirus infection epidemic, combined with the impact of the current round of energy crisis, the cost of European enterprises, especially energy-intensive enterprises soared, the business environment

has seriously deteriorated, enterprises cut production, production shutdown generally increased, bankruptcy tide.

In Germany, for example, where manufacturing is at the core of the European industry chain, energy costs account for about 20% of the cost of energy-intensive industries. The energy crisis has caused Germany's steel and chemical industries to reduce production by 5% and 8% respectively, and the fertilizer industry has even closed 70% of its production capacity in Germany.

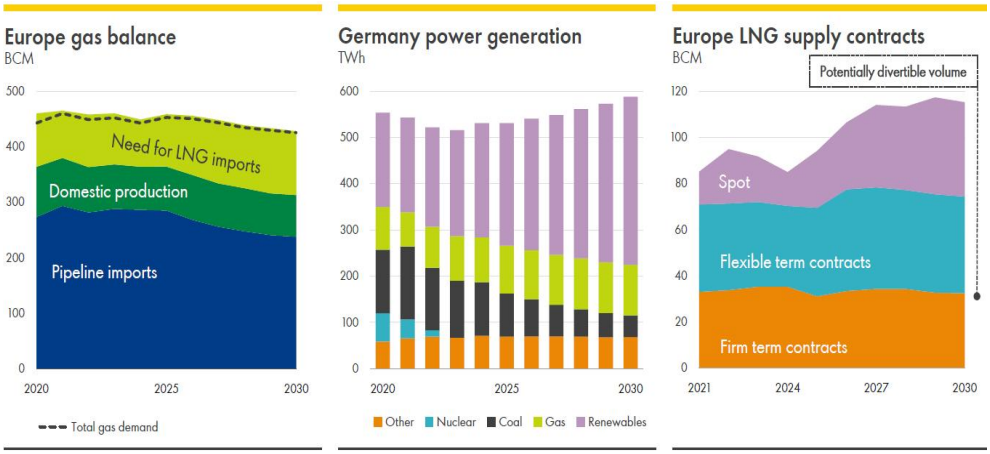
Chemical giant BASF, one of the largest users of German natural gas, has suspended and slowed down production plans globally by 80 and 100 respectively. According to Eurostat. According to Eurostat data, the number of EU business registrations fell by 1.2% in the second quarter of 2022 compared to the first quarter, and bankruptcy filings increased by 2.2% (European Commission, 2022e).

(4). Financial and foreign trade situation worsened

Energy and other commodities are mostly denominated in U.S. dollars, in the devaluation of the euro, forcing high prices of energy imports, superimposed on the rise in energy prices to raise the price of export commodities, Europe's foreign trade deficit has increased. European gas fundamentals show continued volatility (**Figure 22**)

Figure 22

Germany Power Generation and Europe LNG Supply Contracts



Note. From *Shell LNG Outlook (p,27),* by Shell plc, 2023, Shell plc (https://www.shell.com/energy-and-innovation/natural-gas/liquefied-natural-gas-lng/lng-outlook-2023.html). CC BY.

Since the Russia-Ukraine crisis, the EU's energy trade deficit has risen sharply, reaching 491.4 billion euros from January to September 2022, with a trade deficit of 125.7 billion euros with Russia and a 15-fold increase in the trade deficit with another energy producer - Norway - compared to the same period in 2021. The EU and Eurozone also saw a significant rise in their monthly trade deficits.

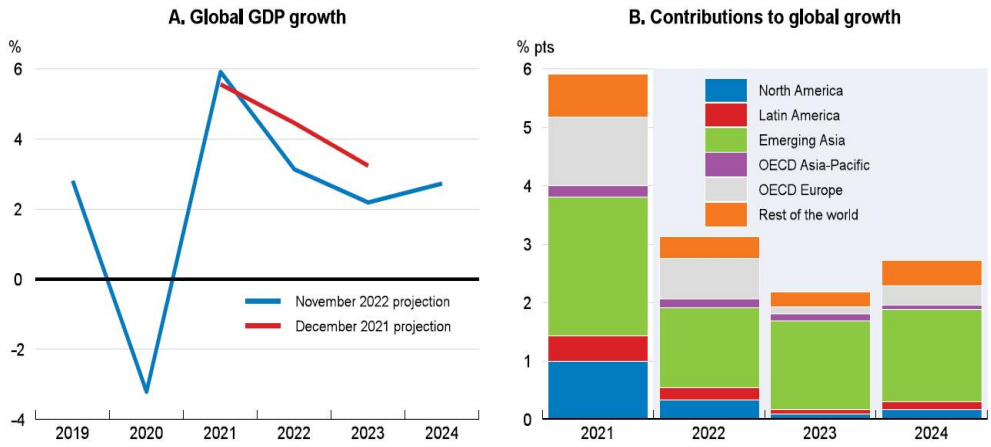
In September 2022, the EU trade deficit was €45.8 billion, compared to €300 million in the same period in 2021, while the Eurozone trade deficit increased by 413% year-on-year. In May 2022, Germany's foreign trade posted its first deficit in 14 years, while in September 2022, France's trade deficit was the largest since records began in January 1970, mainly due to a worsening imbalance between energy imports and exports (Lekiosque Finances, 2022).

(5). Supply chain adjustment, European enterprises move out

The protracted crisis in Ukraine and the strong impact of the energy crisis, the European machinery manufacturing industry, chemical industry, metal smelting industry and other industries with advantages such as enterprises can't afford the cost of raw material prices and other heavy burden, began to adjust the supply chain, and continue to expand investment and develop business outside the region. The relatively low price of the source of investment in the United States to provide huge subsidies to attract European companies to invest in the United States（Shakya et al., 2022), leading to increasingly uneven growth across regions and an expected slowdown in global growth (**Figure 23**).

Figure 23

Global GDP Growth and Contributions to Global Growth



Note. From *OECD ECONOMIC OUTLOOK (p,30),* by OECD, 2022, OECD (https://www.oecd-ilibrary.org/economics/oecd-economic-outlook/volume-2022/issue-2_f6da2159-en). CC BY.

At the same time, many European companies have made additional investments in China, such as BASF's massive investment in Zhanjiang and Volkswagen's increased investment in China. These intensify the fear of de-industrialization within Europe, which may cause irreversible situation to the industrial structure of European industries if the energy crisis continues. The fact that European companies are moving out of the United States and China accelerates the energy transition.

4.1.2 LNG supply chain market

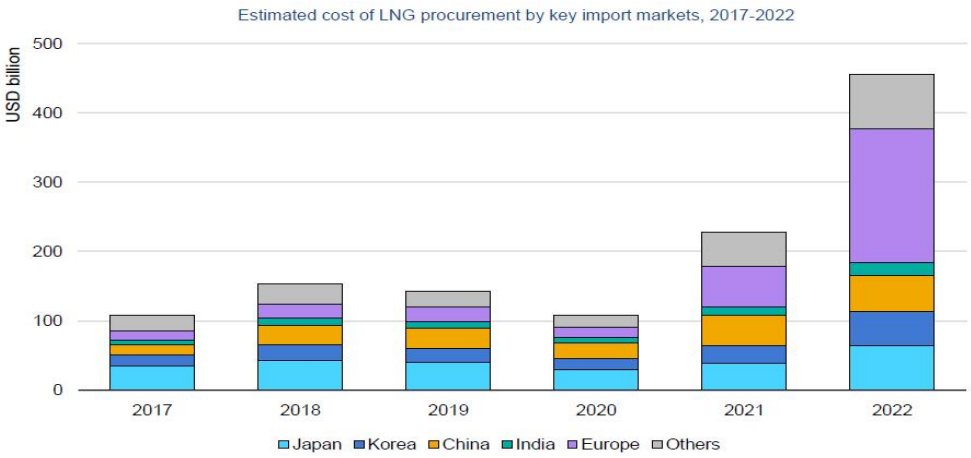
(1). Continued turmoil in the international energy market

The Russia-Ukraine crisis led to an energy crisis, which had a significant impact on the LNG market, especially pushing up global LNG market prices and raising global inflationary pressure through price transmission effects.

Specifically, the Russian-Ukrainian crisis caused geopolitical tensions, coupled with sanctions imposed on Russia by the United States and European countries, as well as causing Russia to implement counter-sanctions, which triggered concerns in international energy markets about possible LNG supply disruptions, and international LNG prices rose sharply as a result, and were in a strong state of high volatility. Global LNG trade doubles in the short term to over $450 billion in 2022(**Figure 24**).

Figure 24

Estimated Cost of LNG Procurement by Key Import Markets



Note. From *Gas Market Report (p,18),* by IEA, 2023, IEA (https://www.iea.org/reports/gas-market-report-q1-2023). CC BY.

As of now, the Russia-Ukraine crisis has not yet shown signs of peace, and the European energy crisis remains serious, leading to continued turmoil in the international LNG market.

(2). It is difficult to get rid of energy shortage in Europe in the short term

In terms of trade geography, the destination of Russia's foreign energy exports is mainly Europe. Taking natural gas as an example, the Soviet Union has been exporting natural gas to Europe through pipelines since the 1960s and 1970s, and the scale of exports has been expanding and the export infrastructure has been improving. Taking natural gas as an example, according to BP statistics, Germany imports 56.3 billion cubic meters of gas from Russia in 2021, accounting for 55.2% of its total imports. From the current point of view, it can be predicted that in the short term, it will be difficult to solve the European energy crisis.

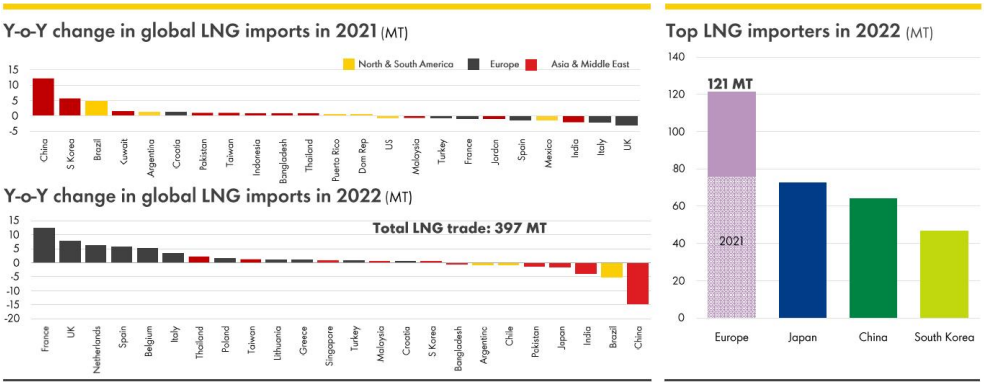
(3). Short-term impact on LNG transportation

In the source of the crisis led to a series of economic impact learned that there are greater difficulties in the short term within the last 3 years in the significant decline in demand for natural gas, an important energy source in Europe, because in 2022 European gas consumption has been relatively reduced under the influence of high prices of LNG, EU initiatives and other factors. Pipeline gas from Russia to the EU fell 37% year-on-year in the first 7 weeks of 2022 (European Commission, 2022f).

For the EU, which imported 155 billion cubic meters of Russian pipeline gas in 2021, the focus in 2023 remains on supply diversification and seeking alternative sources to Russian pipeline gas, which will pull up the growth rate of LNG international trade in the short term, making the international LNG market supply tight. In terms of LNG imports, for the international LNG market, Europe is expected to continue to absorb the entire increment of international LNG resource supply in 2022, and some of the normal demand from Asia will also be transferred to Europe, which will be released in the next 3 years, thus pulling up the price of the Asian LNG market, which will lead to the continuation of high volatility in freight rates, structural demand is emerging in Europe (**Figure 25**).

Figure 25

Change in Global LNG Imports in 2021(MT), Top LNG Imports in 2022(MT)



Note. From *Shell LNG Outlook (p,12),* by Shell plc, 2023, Shell plc (https://www.shell.com/energy-and-innovation/natural-gas/liquefied-natural-gas-lng/lng-outlook-2023.html). CC BY.

Specifically, it is estimated that almost all of the incremental global LNG exports in 2023 will be absorbed by Europe, and more LNG will need to be transferred from Asia to Europe, which means that Europe needs to keep prices high to attract this cargo (Mike et al, 2022).

Natural gas has comparative advantages in consumption and utilization in various key areas, promoting the application of LNG in the field of ships and accelerating the clean transition of ship fuel. At the same time, strengthen training and guidance on LNG ship technology and operation, and improve the safety and operational efficiency of LNG ships. Due to the additional demand in Europe, the global LNG market is disrupted, and emerging market countries that have increased LNG imports in recent years to achieve carbon neutral targets, the incremental domestic gas consumption in 2022 will slow down due to high LNG prices, and this incremental volume is likely to be released in the next 3 years, which will pull up the LNG

market demand in the next 2 to 3 years, and international LNG shipping will be in terms of ship capacity and newbuilding Continued incremental volume.

4.2 Medium and long-term impacts

4.2.1 Slowing down the European economic recovery

The impact of the energy crisis on the European economy and the high inflation rate have slowed down the pace of economic recovery in Europe. According to Eurostat's preliminary estimates, GDP in the EU and the euro area grew only marginally by 0.2% in the third quarter of 2022 compared to the previous quarter. Moreover, the autumn economic forecast released by the European Commission predicts that inflation will remain high in the fourth quarter of 2022 and the first quarter of 2023, and that the EU and the euro area, as well as most member states, experienced a technical recession in the winter of 2022 (EU Commission, 2022).

However, the removal of the epidemic control initiative in 2021 and the first half of 2022 unleashes demand and leads to strong economic growth, with real GDP growth reaching 3.3% overall in 2022. However, real GDP growth in the EU and Eurozone is expected to be just 0.3% in 2023 due to lower real incomes, slower consumption and a slower recovery momentum caused by the energy crisis. The good performance of the labor markets in the EU and the Eurozone added brightness to the European economy amidst unabated inflation. Unemployment rates in the euro area and the EU were 6.6% and 6.0% in September, respectively, both at record lows and close to reasonable levels (EU Commission, 2022J).

Overall, in the medium to long term, the impact of the energy crisis shock on the European economy should not be overestimated, but the development outlook remains highly uncertain, depending on the course of the Russia-Ukraine crisis, the policy responses of the EU and its member states, and the general world economic environment. The energy crisis brought about by the transformation and adjustment of the energy supply and demand structure of the EU and its member states, changes in industrial structure, as well as the differences in economic performance and adaptive adjustment of each country under the shock, will probably last for a long time.

Of course, Europe can accelerate energy substitution and energy transition, large-scale development of new energy sources, especially the vigorous development of renewable energy, and gradually reduce natural gas imports, but this will take a long process.

4.2.2 Impact on LNG transportation

There is a consensus to reduce natural gas demand in EU countries in the medium and long term to 2030. As an important player in the international LNG market, the reduction of natural gas demand in EU countries will have a great impact on the international LNG market.

Firstly, it makes the international LNG trade grow faster and then slower, and the market supply behaves as tight before and then loose, secondly, the energy crisis changes the historical supply pattern, the original Russian LNG supply to Europe tends to shift to Asia, and the US further captures the European gas market share

based on the increase of LNG supply to Europe in the past two years, and thirdly, it changes the slowdown of LNG import from Asian countries.

In terms of global LNG supply capacity and receiving capacity, global liquefaction capacity will reach 520 million tons/year and 600 million tons/year in 2025 and 2027, respectively, and receiving capacity will reach 1.26 billion tons/year and 1.28 billion tons/year, respectively, with the growth of LNG receiving capacity slightly faster than the commissioning of liquefaction facilities, which, when combined with the accounting of infrastructure utilization rate, the LNG market around 2025 The LNG market will show a relatively loosely situation around 2025. The increase in liquefaction capacity is mainly led by Qatar and the United States, with growth in Australia, Russia and Africa, while new LNG receiving terminals are mainly concentrated in China, Vietnam, Thailand, India and other Asian countries, as well as in Germany, France and other European countries under the energy crisis.

From the perspective of the current international environment, first, the high price of LNG is likely to further inhibit the enthusiasm of Southeast Asian countries to invest in the construction of LNG receiving stations in 2025-2030, which may cause a slowdown in the growth of demand for LNG receiving stations due to the pre-epidemic factors and insufficient investment, and second, if the EU can effectively implement the Re-Empowering Europe: Cheap, Safe and Sustainable Energy in Europe Joint Action", Europe deliberately gets rid of its dependence on Russian fossil energy, increases the shipping capacity of LNG from the United States and other sources, and promotes the substitution of renewable energy for fossil energy, but in the current realistic context, there is a greater possibility that Europe will still maintain high demand for the international LNG market until 2024.

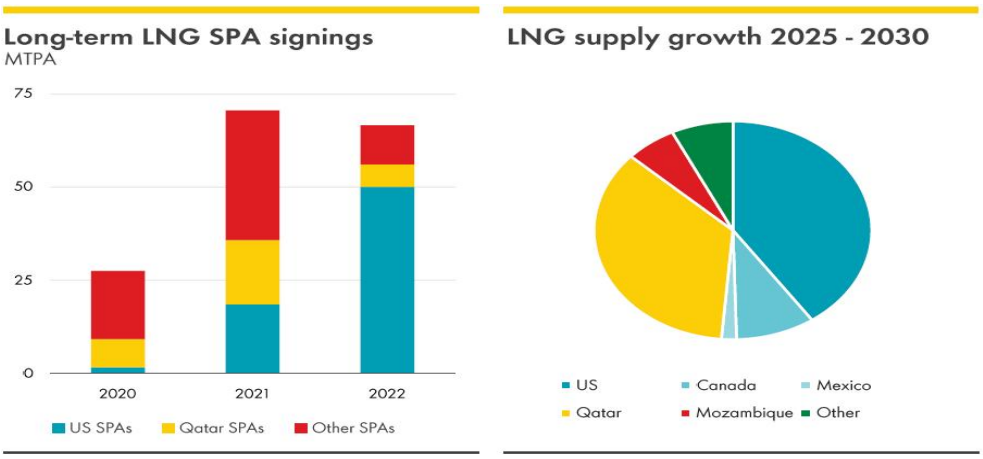
Geopolitical issues will eventually calm down, renewable energy sources will continue to be developed, and demand for LNG will be gradually released, which will further ease the international LNG market, which was originally on the easing side around 2025, with a variety of factors driving the market into an easing cycle. This is for China, where LNG receiving stations are concentrated to be put into operation before 2025, accelerating LNG receiving stations in recent years can play a reserve peaking function, however, under the high volatility of natural gas prices, China's participation in international LNG transportation trade will further expand, China's development in the LNG chain has passed its peak and will unlock some of the incremental LNG demand in the coming years.

4.3 Impact on the United States

The outbreak of the crisis in Ukraine has led to a surge in demand for LNG in energy-starved Europe, providing a major opportunity for the United States to achieve its strategic objectives in Europe and creating good conditions for strengthening the U.S.-European alliance relationship. In this context, the U.S. once again proposed to provide energy security for Europe, especially to increase natural gas exports to Europe. By 2030, around 80% of new LNG supplies will come from Qatar and the US (**Figure 26**)

Figure 26

Long-term LNG SPA Signings and LNG Supply Growth 2025-2030



Note. From *Shell LNG Outlook (p,25),* by Shell plc, 2023, Shell plc (https://www.shell.com/energy-and-innovation/natural-gas/liquefied-natural-gas-lng/lng-outlook-2023.html). CC BY.

On March 25, 2022, the U.S. and Europe signed an energy security agreement that establishes a joint energy security working group to help Europe diversify its gas sources and expand storage facilities. The U.S. has committed to provide incremental resources of 15 billion cubic meters per year on top of the existing 22 billion cubic meters of LNG trade between the two sides, further increasing LNG trade with Europe to 50 billion cubic meters per year by 2030 (European Commission, 2022f).

The U.S. LNG revolution is extremely important to fill the resource demand gap in Europe and reshape the global LNG trade landscape at two main levels. At the short-term level, it will significantly improve the gas resource shortage in Europe in 2022. Currently, new annual global LNG trade volumes are mainly provided through the spot segment, with the US being the world's largest LNG spot supplier, accounting for about 29% of global spot contracts (IEA, 2022a).

Since the intensification of the Russia-Ukraine conflict in 2021, in the face of the surge in European LNG demand in the fourth quarter, the U.S. temporarily withdrew a large amount of spot resources to fill 40% of the resource gap in Europe on its own. In the first half of 2022, the U.S. further increased its resource support, and the share of U.S. LNG in Europe's LNG import resources further increased to 46%, up directly from 26% last year (IEA, 2022b). In June 2022, the EU's trade in imported U.S. LNG surpassed that of Russian pipeline gas for the first time, a historic turnaround that marked the realization that U.S. LNG is replacing Russian pipeline gas, on which Europe has relied for half a century.

In the next three years, approximately 70% of new global LNG production capacity will come from the US. Against the backdrop of the Ukraine crisis, the US is a strategic opportunity to usher in another LNG revolution following the shale gas revolution, thus further accelerating the reshaping of the global LNG trade pattern (**Table 5**).

Table 5

Overview of U.S. LNG Projects in Operation/under Construction

U.S. LNG	Production capacity (10,000 tons/year)	Location	Project Status
Sabine Pass LNG T1-5	2550	Louisiana	In operation
Cove Point LNG	525	Maryland	In operation
Corpus Christi LNG T1-3	1530	Texas	In operation
Cameron LNG T1-3	1350	Louisiana	In operation
Freeport LNG T1-	1530	Texas	In operation

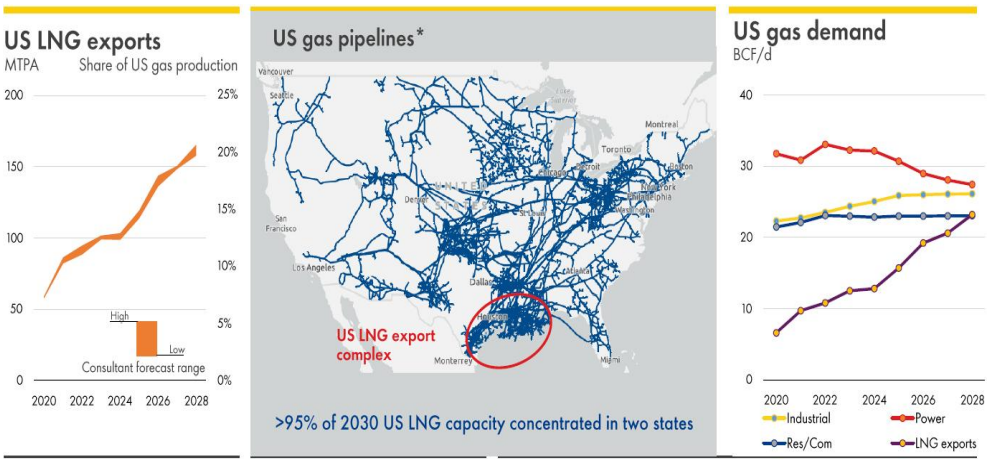
3			
Elba Island LNG	250	Georgia	In operation
Sabine Pass LNG T6	450	Louisiana	Start-up in first quarter of 2022
Calcasieu Pass	1000	Louisiana	Start-up in first quarter of 2022
Golden Pass LNG	1560	Texas	Start-up between 2024-2025

Note. Adapted from Shaping the Grid of the Future, by *Federal Energy Regulatory Commission* (FERC), 2023 (https://www.ferc.gov/). CC BY.

Clarkson expects the US to become the world's largest LNG exporter later this year, with market share expected to grow to 20% from 19% in 2022. The importance of the U.S. as an LNG exporter has increased significantly with the significant expansion of liquefaction capacity, and the agency expects US LNG exports to grow 9% to 85 million tons by 2023, with liquefaction plants operating at full capacity. The growing role of US supply in the global LNG market (**Figure 27**).

Figure 27

US LNG Esports, US Gas Pipelines, US Gas Demand



Note. From *Shell LNG Outlook (p,26),* by Shell plc, 2023, Shell plc (https://www.shell.com/energy-and-innovation/natural-gas/liquefied-natural-gas-lng/lng-outlook-2023.html). CC BY.

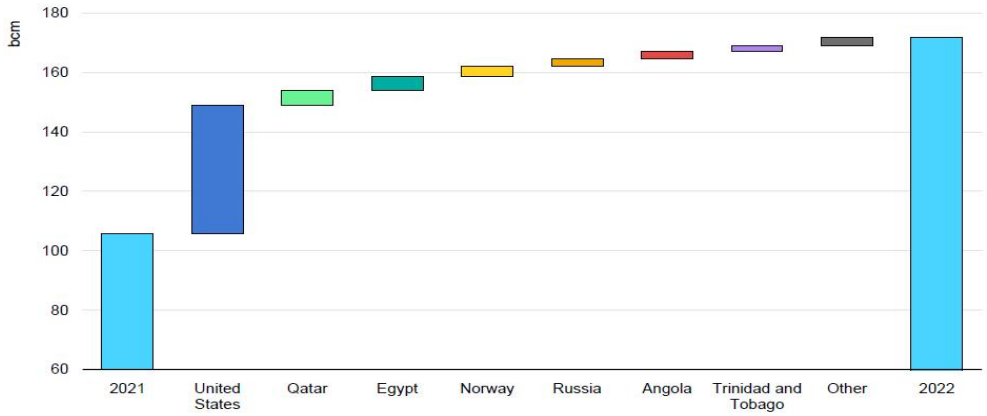
On April 15 2023, the Qatar Gas Exporters Forum, based in Doha, Qatar, released its "Gas Market Report 2023" (IEA , 2022b). According to the report, Qatar will become the world's largest LNG exporter in 2022 with 80 million tons of LNG exports, while Australia will be the second largest exporter in 2021 and the United States and Russia will be the third and fourth largest exporters. Clarkson data showed that US LNG exports reached a record level of 7.3 million tons in March this year, up from a high of 7.1 million tons in April last year. A total of 127 LNG carriers were reported to have called at US ports in March, higher than the previous record high of 123 and 17% higher than the monthly average level of 108 in 2022. LNG carriers remained highly active into April. The data shows that 39 LNG carriers called at US ports in the first ten days of April, the same as the same period in March.

Europe is described as the largest buyer of these cargoes, with about 73% of the LNG being shipped to Europe, The United States provides two-thirds of Europe's

incremental LNG imports (**Figure 28**). Pipeline flows from Russia have slowed to about 10% of the level before the outbreak of the Russia-Ukraine conflict. Clarkson expects European LNG imports to grow 11% this year to a record 136 million tons.

Figure 28

Incremental LNG Import Flows into Europe by Source, 2022 vs 2021



Note. From *Gas Market Report (p,13),* by IEA, 2023, IEA (https://www.iea.org/reports/gas-market-report-q1-2023). CC BY.

Global demand for LNG remains strong, and Clarkson expects global trade to grow by 4.2% to 415 million tons in 2023, given market concerns about energy security caused by the Russia-Ukraine conflict. According to market analysts, uncertainty about LNG demand is increasingly evident after 2027, when additional LNG capacity is likely to fall. Over the next decade, Qatar and the US will compete to

become the world's largest LNG producer. Meanwhile, a sharp rise in US LNG exports will help ease global supply shortages.

4.4 Impact on China

During the period of prominent industrialization, China has achieved rapid development in terms of enterprise production, market consumption, resource import and infrastructure construction, and LNG is entering a rapid development cycle as an energy alternative, with the share of natural gas in China's energy consumption mix rising to 8.9% by 2021 (NEA, 2022). At the same time, China currently relies on imports for its natural gas sources, which are growing at a rate of around 46% and are still hitting new highs year on year (Liu et al, 2022). In contrast to Europe's over-reliance on pipeline gas, China's pipeline gas imports will account for 53.2 billion cubic meters, or 33%, and LNG imports will account for 109.5 billion cubic meters, or 67%, in 2021. The proportional difference between LNG and pipeline gas trade has gradually widened in recent years, and LNG security has become the primary object of China's LNG resource import security (BP, 2022).

The Ukraine crisis has deeply stirred up the global geopolitical landscape and cut the global supply chain, trade chain and financial chain. For China's natural gas trade pattern, although this conflict occurred in Europe and directly hit the resource balance on both sides of the Atlantic Ocean, it also indirectly impacted the Asian LNG market, posing a major challenge to China to ensure national energy security (Dong & Kong, 2017). Safeguarding the stability of the LNG market and the national economy, China, as the world's largest LNG importer, has been affected by the reshaping of the LNG trade pattern in three main ways.

(1) Intensified supply and demand game between the US and China

Although the current global LNG trade pattern reshaping is driven by the Ukraine crisis and Europe is the main battlefield of this conflict, however, from another perspective, China and the U.S. are the top importers and exporters of LNG on the demand and supply sides respectively. 2022 is the year for China and the U.S. to prudently respond to the Ukraine crisis and actively participate in the resource game to jointly promote the pattern reshaping.

As the largest seller in the spot market, the vast majority of U.S. resources have their initial delivery ports in the Asian market, however, after the Ukraine crisis, a significant portion of U.S. resources were diverted from the Pacific Ocean to the other side of the Atlantic Ocean in order to make up for the deficit in the European market. As the largest buyer in the spot and short contract markets, according to the General Administration of Customs statistics for January-May 2022, China's total LNG purchases from Russia amounted to 1.821 million tons, while its total LNG purchases from the U.S. amounted to only 913,000 tons, compared to 1.508 million tons and 2.821 million tons, respectively, in the same period last year (China Customs, 2022a).

It is not difficult to find that while the U.S. is doing its best to fill the resource gap for Europe, China has increased its procurement of Russian resources, especially in February-April 2022, when the Ukrainian crisis broke out, China imported only 62,200,000 tons of LNG resources from the U.S., while purchasing up to 1.165 million tons of Russian resources in the same period. The reshaping of the global LNG trade pattern deeply affects the game of energy supply and demand between China and the United States.

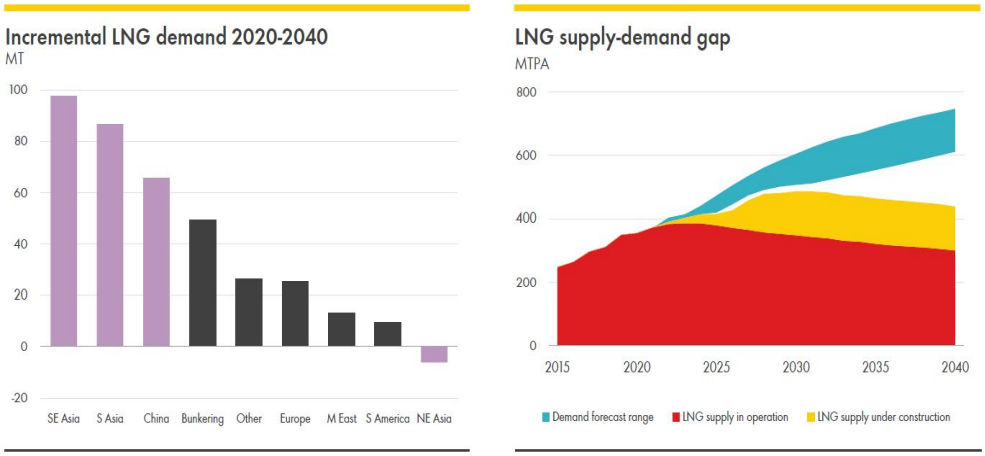
(2) Continued high cost of resource import

The U.S. exports LNG resources to the European market with closer transportation distance and lower freight costs, making it the preferred market for profit-seeking funds. According to China Customs Statistics Online Query Platform, the average price of U.S. LNG resource imports from January to May 2022 was RMB7,584 per ton, nearly twice the average price of Qatari LNG resources and higher than Russian resources with an average price of RMB6,140 per ton (China Customs, 2022b).

At the same time, the reshaping of the global LNG trade pattern has significantly driven up the cost of transporting resources. For example, the daily charter rate for LNG vessels with a capacity of 174,000cbm in the Asia-Pacific region has increased from $40,000 at the beginning of 2022 to $130,000 by mid-year, and the daily charter rate for such vessels in the Atlantic region has increased even more. Expected demand for LNG in Asia (**Figure 29**). The simultaneous rise in global LNG resource procurement costs and transportation costs will exacerbate supply and demand tensions in the Chinese market, significantly raising the cost of operating the Chinese economy and posing greater challenges to the development of the LNG supply chain.

Figure 29

Incremental LNG demand 2020-2040, LNG supply-demand Gap



Note. From *Shell LNG Outlook (p,28),* by Shell plc, 2022, Shell plc (https://www.shell.com/energy-and-innovation/natural-gas/liquefied-natural-gas-lng/lng-outlook-2022.html). CC BY.

(3) Risk of supply-demand imbalance in the market

According to China Customs statistics, from January to May 2022, China's LNG imports totaled 26.49 million tons, down 19.6% year-on-year. China's LNG imports in 2022 will be roughly the same as in 2021, ending the previous years of continuous high growth (China Customs, 2022b) . The reason for this is mainly because the supply of long-term contracts lags behind market demand, the spot contract prices are too high, the production and operation of enterprises have a dissuasive effect, resulting in a significant reduction in resource imports or even stop purchasing. In the second half of the Eurasian market resources to replenish inventory, large-scale resource scramble, price escalation competition.

It is worth noting that the current price fluctuations in the LNG transportation market are the result of structural rather than stressful market equilibrium, which means that over a period of time, intermittent supply and demand imbalances, international LNG

energy disconnections and offsets may become the market norm, which will seriously threaten the economic and social stability of China and impact the bottom line of our energy security.

Chapter 5 Discussion and Recommendations

A country's economic development without a stable energy supply and a secure energy system is hardly a permanent foothold for development in the world, and Europe is still facing a major gas crisis.

Uncertainty about the crisis in Ukraine has led to market concerns about energy supply disruptions and Russian gas is being withdrawn from the spot market. This is a risk for our country as a major importer of Russian natural gas. If the geopolitical environment continues to deteriorate, it will add tension to the challenging market situation. LNG demand is expected to grow at a compound annual growth rate of 5.8% between 2020 and 2027 (Grand View Research, 2019).

The Ukraine crisis ushered in the third round of traditional energy supply structure transformation. From the current situation, Europe and Russia's position on energy decoupling is firm enough, and the attitude of the US LNG revolution is also firm enough, but in the long run, there are still great uncertainties in the resolution of many key issues, such as whether the speed of US resources production can keep up with the progress, whether the European LNG receiving capacity can be smoothly upgraded, and whether the development rhythm of new energy transformation can be

accelerated. Therefore, the establishment of a sound gas supply security mechanism is a necessary tool to reduce our geopolitical risks in an increasingly complex and uncertain international political scenario.

Factors such as the development of the country's economy and population growth have led to a vast scope for the LNG industry, thus increasing the amount of LNG imports. The process of continuous construction of the national gas supply security mechanism reflects the continuous development of the LNG industry in China, thus promoting the highly quality development of the energy economy. Whether from the perspective of energy security, industrial transformation or economic cost, this reshaping of the global LNG trade pattern will have an extremely far-reaching impact on China, and it is particularly important to enhance trade security and risk control capabilities (Lin, 2020).

For the whole industry chain of LNG shipping, we discuss in the short term, mediumly and long-term elements respectively, and put forward suggestions to adapt to China's LNG shipping by combining political, economic and environmental multiple elements.

5.1 Regulating short-term price fluctuations

Faced with the impact of the European energy crisis, China should strengthen the LNG reserves and the basic reserves of imported LNG guaranteed at sea to cope with the short-term high price fluctuations.

China has turned into the world's largest importer of LNG, on the one hand, increase its participation in the JKM price window and strive to enhance its influence on the

established market prices, and, on the other hand, accelerate the construction of the China Gas Trading Hub to create an independent benchmark price for natural gas based on Chinese market rules and reflecting the needs of domestic users, so as to actively seek a greater voice in the Northeast Asian market and the international energy market.

First, China should strengthen the construction of LNG reserves. At present, China's LNG reserve capacity is relatively low, while the demand for LNG is increasing. Therefore, in order to emerge from the effects of the European energy crisis. China needs to accelerate the construction of LNG reserves and increase the amount of LNG reserves to guarantee national energy security.

Secondly, China should increase the maritime security of the basic reserves of imported LNG. as a flammable and explosive dangerous product, LNG needs to take a series of safety measures for storage and transportation. In the process of LNG import, maritime transportation is an important link. In order to guarantee the safety and stability of LNG import, China should strengthen the maritime guarantee of imported LNG base reserves. Specific measures include:

(1). build safe and efficient LNG vessels. LNG vessels are the main means of transportation for LNG import, so building safe and efficient LNG vessels is the key to guarantee the safety of LNG import.

(2). strengthen the safety management of LNG import ports. LNG import ports are the key link of LNG import, and must strengthen the safety management to ensure the safety and stability of LNG import. Specific measures include building safe and

efficient LNG unloading facilities, strengthening safety inspection and supervision of LNG import ports, etc.

(3). Establish LNG emergency response mechanism. In the process of LNG importation, unexpected events may affect LNG importation. Therefore, the establishment of LNG emergency response mechanism can effectively respond to the unexpected events and guarantee the safety and stability of LNG import.

To sum up, in order to cope with the impact of the European energy crisis, China should strengthen the construction of LNG reserves and the offshore guarantee of imported LNG base reserves to ensure the safety and stability of LNG imports.

5.2 Balancing long-term supply and demand capacity

LNG receiving station is the key link of LNG import, and its construction and development are of great significance to the balance of LNG supply and demand. The expansion of the LNG receiving terminal is necessary to address current reserve stock levels to meet the demand for LNG imports. Meanwhile, the diversified construction of LNG receiving stations, including different types of receiving stations such as onshore and offshore, can be actively promoted.

The peaking capacity of LNG receiving terminals, during LNG imports, there will be an imbalance between LNG supply and demand when suffering from short-term fluctuations. Therefore, improving the peaking capacity of LNG receiving stations can better meet the market demand. Specific measures include strengthening the construction of reserve capacity and peaking capacity of LNG receiving stations to improve the flexibility and reliability of LNG supply. LNG benchmark price

regulation center is an important part of the LNG market, and its construction and development are of great significance to the balance of LNG supply and demand and price stability. Establishing the legal system and regulatory mechanism of LNG benchmark price regulation center, the construction of LNG benchmark price regulation center needs to establish a perfect legal system and regulatory mechanism to ensure the fairness, justice and transparency of its operation, and strengthen the technical support and data analysis of LNG benchmark price regulation center.

The LNG benchmark price regulation center needs to establish a comprehensive technical support and data analysis system to provide accurate and timely price information and market analysis to provide better services to market participants. Promote the international development of LNG benchmark price regulation center. the LNG benchmark price regulation center should actively promote international development, attract domestic and foreign market participants, strengthen international cooperation and exchange, and promote the globalization of the LNG market.

In summary, effectively regulating LNG reserve capacity and accelerating the construction of a price regulation mechanism are important measures to implement China's ability to balance supply and demand in the LNG shipping market.

5.3 Regulatory Measures for LNG Shipping in China

(1). Expanding diversified channels of resource import

After the energy crisis, the United States also became the world's largest supplier of natural gas resources after Russia. Since 2021, China has increased resource procurement efforts with the U.S. and Russia respectively, and China has signed new

U.S. LNG long contracts of 10.5 million tons for the whole year, accounting for 39% of the total number of new long contracts signed globally. Also, the gas transmission capacity of the Russian-Chinese gas pipeline East Line has been steadily increasing, and the two sides signed a new 10Bcf/year Far East pipeline gas supply agreement in early 2022, further enhancing the long-term resource security capacity.

The Ukraine crisis has made China the common buyer and the largest potential buyer of US and Russian natural gas resources, grasping the favorable market position and ensuring stable supply of resources. On the Russian side, China focuses on the Far East market trade transfer to undertake, and accelerate the progress of LNG project capacity construction such as Yamal. For the United States, China actively participates in the procurement of LNG projects and enhance the design of force majeure contracts, and reduces the policy impact brought by changes in Sino-US relations. At the same time, China actively expands cooperation with other resource countries and form LNG international procurement alliances under the guidance of the government to improve the bargaining power of resources.

(2). Diversification of China's LNG import destinations

Diversification of China's LNG import destinations can help reduce the risk of a single supply source and improve the stability and reliability of the supply chain. China takes various measures to strengthen market research and analysis of LNG import destinations in the era of energy crisis; to understand the LNG demand and market situation in each region, formulate corresponding import strategies and select suitable import destinations; to build LNG receiving stations in each import destination to improve LNG import capacity and supply capability and reduce the risk of a single import destination; and to strengthen the safety management and

guarantee of LNG import destinations to ensure the safe transportation and use of LNG.

(3). Construction of LNG alternative routes

The construction of LNG alternative routes can help reduce the cost and risk of LNG transportation and improve the reliability and flexibility of the supply chain. China makes great efforts to strengthen the market research and analysis of LNG alternative routes; to understand the demand and market situation of LNG alternative routes and develop corresponding construction plans; to research and develop LNG alternative route technology, improve transportation efficiency and safety, and promote its application; to strengthen the cooperation and exchange of LNG alternative routes at home and abroad, and to promote the sharing and cooperation of technology and market.

(4). Building China's Super LNG Fleet

The establishment of China's super LNG fleet will help improve the efficiency and safety of LNG transportation, reduce transportation costs and risks, and also help improve China's LNG transportation capacity and market competitiveness. China aims to formulate the strategic plan and target for LNG fleet construction; clarify the objectives and development route of LNG fleet construction and formulate specific implementation plans; strengthen the technology research and development and promotion of LNG fleet construction; develop LNG vessel technology to improve transportation efficiency and safety; increase the financial support and investment in LNG fleet construction to improve the speed and scale of construction.

Offshore LNG transportation involves greater safety risks and requires the establishment of a comprehensive risk analysis and assessment mechanism to ensure

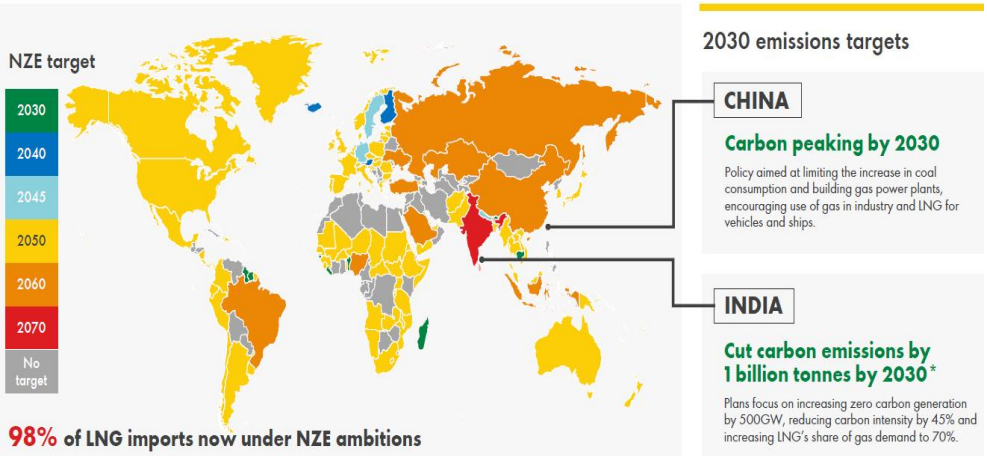
the safety and reliability of LNG transportation. Establish a comprehensive regulation and management mechanism to strengthen the safety regulation and management of offshore LNG transportation. Establish a safety management system for offshore LNG transportation, including safety standards, safety procedures, safety inspections and safety training, etc. Establish a comprehensive emergency plan and rescue system for offshore LNG transportation to respond to emergencies and accidents in a timely manner.

(5). Promoting LNG Clean Energy Transition

Compared with traditional fossil energy, natural gas is a clean energy source, a low-carbon industry and a green industry (Azad & Chakraborty, 2020). Therefore, the increase of LNG in China's energy share can help promote the greening of China's energy structure. As the two largest countries in the world with large populations are China and India in Asia, which have set 2030 emission targets for carbon emissions, the net zero target covers 88% of global emissions (**Figure 30)**. China will increase the policy support and industrial support for LNG as a clean energy source, promote the development of LNG decarburized energy and also strengthen the promotion of LNG clean energy and increase public awareness and acceptance of LNG clean energy.

Figure 30

Top Carbon Emitters Set 2030 Emissions Targets



Note. From *Shell LNG Outlook (p,5),* by Shell plc, 2022, Shell plc (https://www.shell.com/energy-and-innovation/natural-gas/liquefied-natural-gas-lng/lng-outlook-2022.html). CC BY.

LNG technology innovation and R&D should strengthen to improve LNG's clean energy performance. Through technological innovation and R&D, improve the combustion efficiency and CO_2 emission level of LNG to further reduce the environmental impact of LNG. Promote the synergistic development of LNG and renewable energy, and establish a complementary relationship between LNG and renewable energy. Achieve diversification and clean transformation of the energy mix and improve market sustainability through the synergistic development of LNG and renewable energy.

In summary, in response to the impact of the European energy crisis on the LNG shipping market, we need to take a series of measures to strengthen LNG reserves, cultivate the ability to balance supply and demand, regulate the maritime supply chain, and promote the clean energy transition. These measures will help to cope

with the changes and risks in the market and promote the smooth development of China's LNG shipping market.

Chapter 6 Conclusion and Outlook

6.1 Conclusion

As a result of the energy crisis, Europe has been forced to move away from Russian fossil energy supply sources and action plans, which has had a negative impact on geopolitics, regional economies, environmental protection, social impact, and technological innovation. In the short- and medium-term, this will have a significant impact on Europe and the global LNG market.

Short-term supply constraints caused by the surge in European gas demand have caused international LNG prices to fluctuate sharply away from supply and demand fundamentals. Prices are expected to stay high for almost three years as European gas reserves targets are met and global LNG prices return to fundamentals driven by supply and demand.

Long-term, it will change how the global gas market flows, with Russian gas continuing to flow faster to Asia and Asia's demand for global LNG slowing down. Some of the additional volumes will be released in the coming years, leaving a tight supply of global LNG and a loose supply behind.

This study takes the LNG supply chain as the object of study and examines how to ensure the security of China's natural gas offshore supply in the context of the European energy crisis, and analyzes the PEETS macro factors, mainly answering the following questions:

(1). What is the current situation of the international natural gas supply chain? What is the current world and Chinese gas supply, demand and supply?

(2). What are the impacts of the European energy crisis on the gas supply chain?

(3). How can reasonable measures be established to deal with the impact of LNG supply in the short and medium to long term in the event of an energy crisis?

(4). What are the shortcomings in establishing norms and studying the subject of the development of LNG shipping?

Based on this, and in response to the above issues, this dissertation draws conclusions on China's response to international LNG price volatility and LNG shipping.

(1) The LNG market supply and demand in 2023 is on the tightening side, with spot and shipping prices in a high and oscillating market environment. At the moment, in the context of Europe's further disengagement from Russian gas, the EU's achievement of storage targets will continue to drive up demand for the international LNG market, keeping LNG prices at high levels that are out of line with fundamentals.

(2) China has entered the era of industrialization and population flow to large residential consumption, and therefore has to maintain the balance by way of importing LNG. The tense environment of the international LNG market has forced the LNG receiving stations put into operation in China in the next two years to play the reserve function. Accelerate the establishment and perfection of the LNG receiving station reserve peaking mechanism, continue to increase participation in the international LNG spot market capacity, and cultivate the ability of LNG receiving stations to reserve and regulate the balance of supply and demand in the domestic and international LNG market.

(3) The LNG supply and demand imbalance phase is extremely disruptive to the international LNG market, and in the long run, China should accelerate its pace and take the initiative to build a benchmark price center for LNG in China. Natural gas related companies should promote a unified market, promote the linkage of international contracts to Chinese natural gas prices, increase China's voice in the international LNG shipping market, promote the construction of a shipping center for the Chinese natural gas market, and strengthen their participation in the construction of the international LNG supply chain. Strengthen LNG reserves, cultivate the ability to balance supply and demand, regulate the supply chain, promote clean energy transformation, empower China's entire natural gas industry chain, propose to accelerate structural reform of supply, reduce external dependence, and improve a more favorable market environment.

(4) On the demand side, both energy shortage and the need for decarbonized environment will pull natural gas consumption to form high quality demand, and on the technology side, due to the strong support for science and technology

innovation, Due to environmental demands, the technology of LNG shipping is stepping up to the technological level of developed countries. The construction of a clean, low-carbon, safe and efficient energy supply system will comprehensively promote the high-quality development of China's energy economy, reduce geopolitical risks and promote the benign development of LNG shipping.

6.2 Research deficiencies and Outlook

6.2.1 Research deficiencies

Using the PEEST research methodology, this dissertation provides an insight into the relationship between the European energy crisis model and China's LNG supply security, guiding how China can ensure the security of its LNG supply. The main deficiencies are:

Firstly, because of the sudden occurrence of the crisis in Ukraine, the geopolitical related public data are rarely disclosed, and at the same time limited to the problem of confidentiality of some data are difficult to obtain, so it is difficult to directly obtain and quantify the data in the evaluation of the security of supply of LNG shipping, so this paper is insufficient in the empirical test.

Secondly, since the volatile situation of LNG price due to the European energy crisis is less than two years, the transformation of the relevant new international energy pattern and the actual implementation of the EU policy as well as the specific details of the effect have not been fully reflected. As a result, there is a lack of multiple

perspectives as well as professional depth when analysis the development patterns of LNG supply shipping.

With the development and construction of the whole LNG industry chain in China, the future direction of this research topic is to strengthen the statistics and collection of first-hand data of the international LNG industry chain, and then to conduct empirical analysis based on the establishment of the relevant model index system to highlight the value of the research.

6.2.2 Outlook

In the future, with the continuous adjustment and transformation of global energy structure, LNG shipping market will face new opportunities and challenges. We need to strengthen the research and analysis of global LNG market, grasp the market changes and trends, and provide strong support for the development of China LNG shipping market. At the same time, we also need to strengthen technological innovation and talent training to improve the competitiveness and core competitiveness of the LNG shipping market. In the future, China LNG shipping market will continue to play an important role and make greater contribution to promote clean energy transformation and economic development.

(Word Count: 14900; Tables, figures and references are not included)

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