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Department of Sociology, Economic
Theory and International Processes
38.04.01 Economics
International Economics and Business

GRADUATION THESIS

on

**China's foreign trade in energy resources: current state
and development prospects**

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Institute of Economics and Administration
Department of Sociology, Economic Theory and International Processes
Field of study 38.04.01 Economics,
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ASSIGNMENT
FOR THE GRADUATION THESIS OF

Master's degree student Jia Ruirui, group 24ЭЭВам1, full-time mode of study

1 The topic of the graduation thesis: China's foreign trade in energy resources:
current state and development prospects

was approved by the university order
dated « ____ » _____ 20 ____ no. _____

2 The deadline for the Master's degree student to complete the graduation thesis is
15.06.2026.

3 The input data for the graduation thesis is the regulatory and legal framework,
scientific literature and reference books, and Internet data.

4 The list of issues to be studied includes global context of international energy
trade development; analysis of the current situation of China's international energy trade;
development prospects and strategic choices of China's international energy trade.

5 The list of visuals contains tables and figures.

6 The date of setting the assignment is 8.10.2024.

Academic adviser _____ / Vlazneva S. A. /
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The assignment was accepted by Master's degree student _____ / Jia Ruirui /
(signature) (full name)

Schedule for completing the graduation thesis

№ п/п	Content of the thesis	Deadline for completion	Due date, signature of the academic adviser
First year of study			
1	Substantiating of the research topic and methodology, subject and object of research	1.09.2024 – 31.10.2024	
2	Framing the scientific concept of research	1.11.2024 – 18.12.2024	
3	Collection of scientific literature for the thesis	19.12.2024 – 15.01.2025	
4	Substantiating the relevance, concept, and novelty of the research	16.01.2025 – 19.02.2025	
5	Framing of a detailed plan and layout of the research	20.02.2025 – 12.03.2025	
6	Studying new literature sources within the topic of the thesis	13.03.2025 – 26.03.2025	
7	Conducting theoretical research within the first chapter of the thesis	27.03.2025 – 30.04.2025	
8	Preparing the first chapter of the thesis	1.05.2025 – 30.06.2025	
Second year of study			
9	Conducting analytical research within the second chapter of the thesis	1.09.2025 – 22.10.2025	
10	Preparing the second chapter of the thesis	23.10.2025 – 24.12.2025	
11	Conducting analytical research within the third chapter of the thesis	25.12.2025 – 25.02.2026	
12	Preparing the third chapter of the thesis	26.02.2026 – 21.04.2026	
13	Preparing the introduction and conclusion	22.04.2026 – 12.05.2026	
14	Completing the graduation thesis	13.05.2026 – 27.05.2026	
15	Handing in the thesis for compliance control and antiplagiat	28.05.2026 – 11.06.2026	
16	Getting acquainted with the feedback and review	13.06.2026	
17	Presenting the written thesis	15.06.2026	

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The assignment was accepted by Master's degree student _____ / Jia Ruirui /
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Summary

The graduation thesis comprises 98 pages, 3 chapters, 11 figures, 5 tables, 66 sources.

INTERNATIONAL TRADE, ENERGY TRADE, EXPORT, IMPORT, CHINA, OIL, GAS, COAL

Object of the research is China's foreign trade in energy resources as an integral segment of the global energy system.

The research purpose is to analyze the current state and development prospects of China's international energy trade.

The methodological framework of the paper is formed by system approach, analysis and synthesis, statistical and comparative methods. To display identified economic dependencies graphical method was applied.

The results of research include: structure and flow characteristics of global energy trade was studied; restructuring effects of global energy transition on trade patterns were identified; structure and scale evolution of China's international energy trade was studied; driving factors and potential of China's international energy trade development were examined; development prospects and strategic choices of China's international energy trade were identified.

The novelty of the work is trends and prospects for the development of energy trade cooperation of China and strategies to strengthen China's relationship with energy trading partners are revealed.

The research contributes to the theory of international trade by adapting the concept of energy security to the conditions of the green transition and by identifying the mechanisms through which geopolitical shocks restructure comparative advantages in energy-intensive trade flows.

The practical significance is determined by the development of evidence-based recommendations for China's state energy policy and foreign trade strategy. The identified structural shifts in global flows and the assessment of driving factors provide an analytical foundation for optimising import diversification routes, adjusting strategic petroleum and gas reserve targets, and prioritising overseas energy infrastructure investments. The

proposed strategic pathway for a safe, resilient, and green trade system offers a concrete framework for aligning the activities of China's national energy corporations and export-oriented clean technology manufacturers with the dual-carbon goals.

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Introduction

The relevance of examining China's foreign trade in energy resources is dictated by the country's unique position as the world's largest energy consumer and the predominant importer of crude oil, natural gas, and coal. The relevance of this research is in the following aspects. Against the backdrop of deepening global energy transition, restructuring of geopolitical patterns, and reforms in the international energy governance system, the scale, structure, and flow of international energy trade are undergoing profound adjustments, with the strategic, economic, and ecological attributes of energy becoming increasingly prominent. As the world's largest energy consumer and importer, China's international energy trade not only concerns domestic energy security and stable supply, as well as high-quality economic and social development, but also exerts far-reaching impacts on the global energy trade landscape and energy governance systems. Master thesis takes China's international energy trade as the research object, systematically reviews the macro background of global energy trade development, comprehensively analyzes the category structure, scale evolution, source locations, and trade channel layout of China's international energy trade, and clarifies China's role positioning in the global energy trade system; deeply examines the domestic, international, technological, and institutional factors driving the development of China's international energy trade, identifies core challenges such as geopolitical risks, contradictions in low-carbon transition, insufficient governance discourse power, and trade barriers in new energy; in conjunction with global energy development trends, forecasts the development prospects of China's international energy trade from 2024–2027 (short-term) and 2028–2035 (medium-to-long-term), and ultimately proposes a strategic path to build a secure, resilient, and green China's international energy trade system, providing theoretical support and practical guidance for the high-quality development of China's international energy trade.

Object of the research is China's foreign trade in energy resources as an integral segment of the global energy system.

Subject of the research is the structural dynamics, geographical reorientation, factor determinants, and prospective trajectories of China's energy imports and exports.

The research purpose is to analyze the current state and development prospects of China's international energy trade. In order to achieve it we need to complete the following tasks:

- to characterize the commodity structure and principal flow characteristics of global energy trade and evaluate the restructuring effects of the global energy transition on established trade patterns;
- to conduct an analysis of the evolution of the scale and commodity structure of China's international energy trade;
- to systematize the core internal and external challenges facing the development of China's international energy trade;
- to develop scientifically grounded medium- and long-term prospects for China's international energy trade;
- to propose a strategic pathway for building a secure, resilient, and green international energy trade system for China.

The main research methods used are literature research, qualitative analysis and comparative analysis. And the following methods also widely used in this thesis: quantitative analysis; quantity research method; experience summary method and descriptive research. This study focuses on the current status and trends of China's energy trade and aims to promote the future development of China's energy trade.

The novelty of the work is trends and prospects for the development of energy trade cooperation of China and strategies to strengthen China's relationship with energy trading partners are revealed.

The research contributes to the theory of international trade by adapting the concept of energy security to the conditions of the green transition and by identifying the mechanisms through which geopolitical shocks restructure comparative advantages in energy-intensive trade flows.

The practical significance is determined by the development of evidence-based

recommendations for China's state energy policy and foreign trade strategy. The identified structural shifts in global flows and the assessment of driving factors provide an analytical foundation for optimising import diversification routes, adjusting strategic petroleum and gas reserve targets, and prioritising overseas energy infrastructure investments. The proposed strategic pathway for a safe, resilient, and green trade system offers a concrete framework for aligning the activities of China's national energy corporations and export-oriented clean technology manufacturers with the dual-carbon goals.

The work structure is determined by the purpose and tasks decided in the work. The introduction section primarily elaborates on the research background and significance of this study, reviews the current domestic and international research landscape, clarifies the research approach, content, and methodology, identifies the innovative aspects and limitations of the study, and lays the foundation for the entire research framework. Chapter 1 establishes the global context of the research. It reveals the commodity structure and key characteristics of international energy resource flows; analyses the transformative effects of the global energy transition that are restructuring established trade patterns for both fossil fuels and clean technologies; and identifies the new features and emerging trends in energy geopolitics, including market fragmentation and shifting logistical routes. Chapter 2 presents an empirical analysis of the current state of China's foreign trade in energy resources. It assesses the evolution of the scale and commodity structure of imports and exports; systematises the key economic, technological, and political drivers of development and evaluates the growth potential; and identifies and analyses the principal internal and external challenges confronting China's energy trade, ranging from infrastructure constraints to sanctions-related risks. Chapter 3 adopts a forecasting and strategic character. Drawing on the identified factors and challenges, it develops medium- and long-term prospects for the development of China's energy trade; and proposes a strategic pathway for building a secure, resilient, and green international energy trade system that integrates energy security imperatives with climate commitments. In the conclusion section, the main research findings of this study are summarized.

Chapter 1 Global context of international energy trade development

1.1 Structure and flow characteristics of global energy trade

Evolution of Global Energy Trade Scale The evolution of global energy trade scale is closely linked to factors such as global economic development, changes in energy demand, and technological progress, generally exhibiting characteristics of «sustained growth with periodic fluctuations». Since the 20th century, with the advancement of industrialization, global energy demand has continued to rise, leading to a steady expansion of energy trade scale. Entering the 21st century, major events including the 2008 global financial crisis, the 2020 COVID-19 pandemic have caused periodic fluctuations in global energy trade scale, yet the long-term growth trend remains unchanged [39].

According to the BP Statistical Review of World Energy (2024), global energy trade volume increased from 15 billion tons of standard coal equivalent to 21 billion tons during 2010–2023, with an average annual growth rate of 2.4 %. The period from 2010 to 2019 saw sustained steady growth at 3.2 % annually, driven by global economic recovery and rapid development in emerging economies that boosted energy demand and expanded trade scale. In 2020, however, the COVID-19 pandemic triggered global economic recession and a sharp decline in energy demand, causing total energy trade to drop 5.8 % year-on-year to 18.5 billion tons of standard coal equivalent [47]. From 2021 to 2022, as global economic recovery rebounded and energy demand recovered alongside supply chain disruptions, global energy trade volume surged, growing by 6.2 % in 2022 and 4.5 % in 2023, returning to pre-pandemic growth levels [40] (figure 1.1).

From the perspective of trade volumes across energy categories, fossil fuels remain the dominant force in global energy trade, while renewable energy has experienced rapid growth. In 2023, global fossil fuel trade reached 18.5 billion tons of standard coal equivalent (SCE), accounting for 88.1 % of total energy trade. Crude oil trade dominated

with 9.2 billion SCE (43.8 %), natural gas trade at 5.8 billion SCE (27.6 %), and coal trade at 3.5 billion SCE (16.7 %).

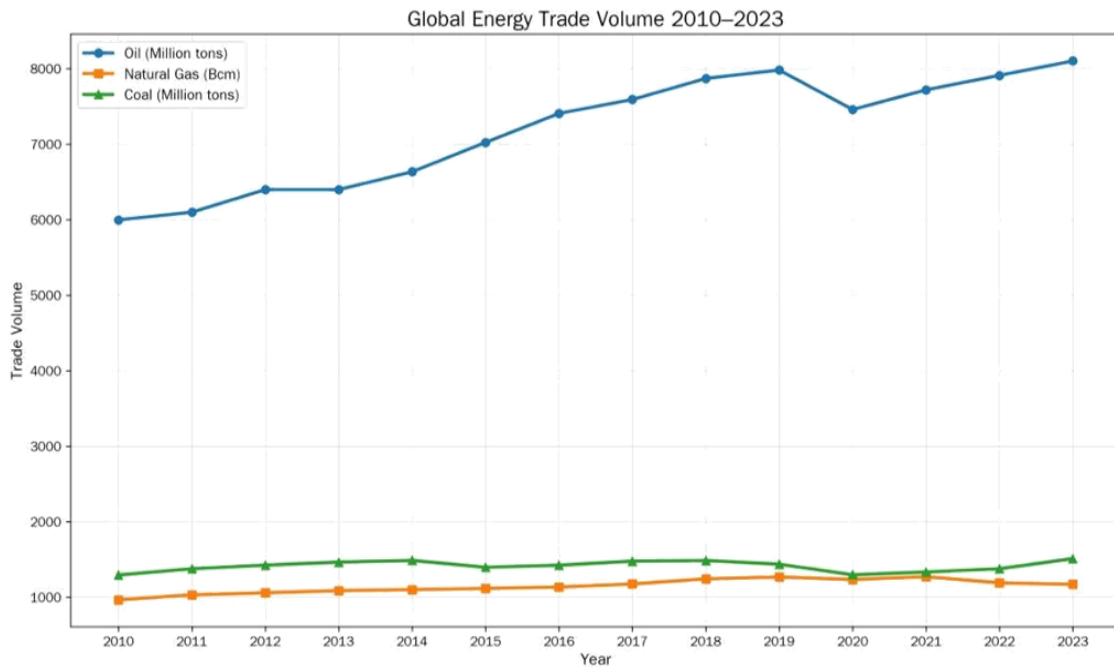


Figure 1.1 – Global energy trade volume by fuel [18]

Renewable energy trade (including photovoltaic modules, wind power equipment, and biomass energy) totaled 2.5 billion SCE, representing 11.9 % of global energy trade (figure 1.2). Although still a relatively small share, its growth rate significantly outpaced fossil fuels. From 2010 to 2023, renewable energy trade maintained an annual growth rate of 12.3 %, far exceeding the average growth rate of global energy trade, emerging as a new growth driver in the sector [26].

Geographically, Asia, North America, and Europe form the core regions of global energy trade, collectively accounting for over 85 % of worldwide energy trade volume. In 2023, Asia's energy trade reached 8.5 billion tons of standard coal equivalent (SCE), representing 40.5 % of global consumption. As the world's largest energy importer, it primarily relies on energy imports. North America's energy trade totaled 5.8 billion SCE, constituting 27.6 % of global demand, demonstrating a balanced approach between imports and exports.

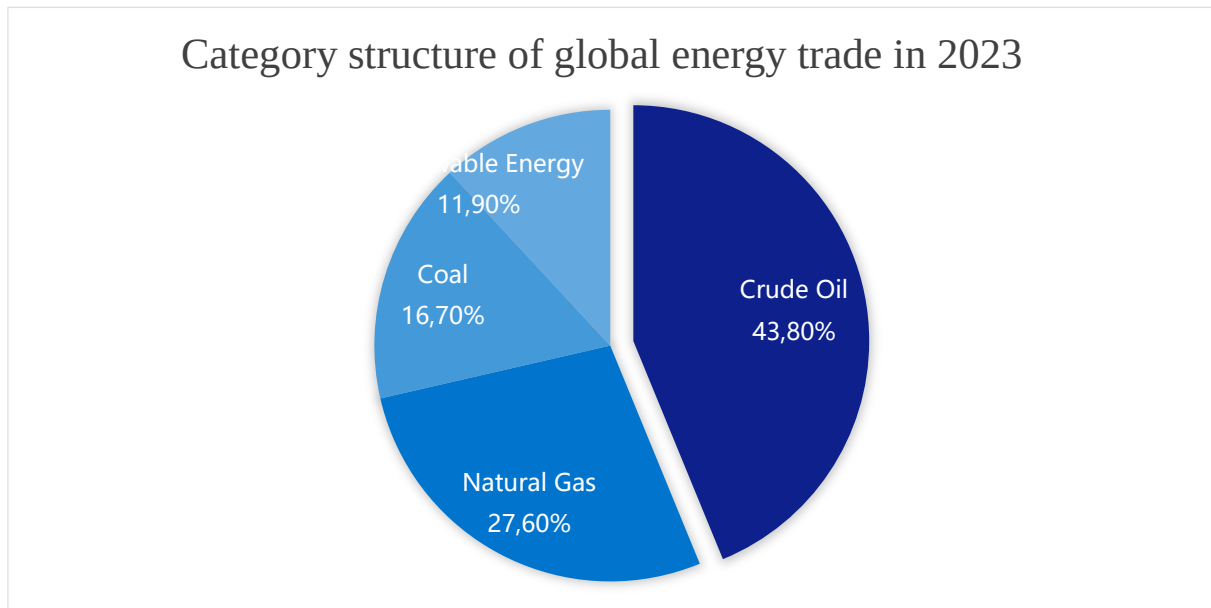


Figure 1.2 – Global energy trade volume by fuel [18]

The United States has emerged as a pivotal energy exporter in this region. Europe's energy trade volume stood at 4.2 billion SCE, accounting for 20 % of global demand, with a heavy dependence on imported energy sources [37] (figure 1.3).

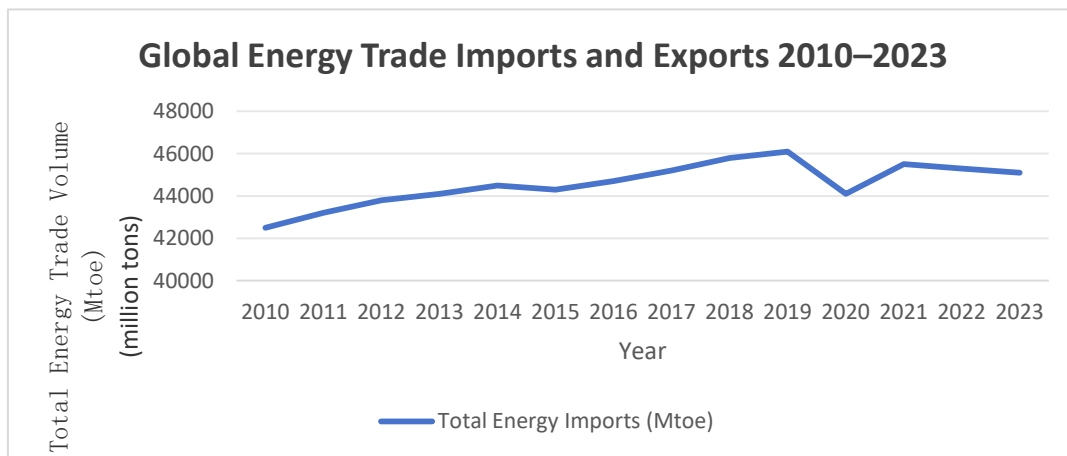


Figure 1.3 – Global energy trade imports and exports, 2010–2023 [18]

The global energy trade structure primarily comprises two aspects: product category structure and regional distribution. With the advancement of global energy transition, the energy trade structure is undergoing profound adjustments, exhibiting characteristics of

dominance by fossil fuels, rapid growth of renewable energy, clear regional specialization, and prominent multi-polarization trends.

From a category structure perspective, global energy trade remains dominated by fossil fuels, though the composition continues to improve with renewable energy's share steadily increasing. As previously noted, fossil fuels accounted for 88.1 % of total global energy trade volume in 2023, maintaining their position as the primary energy source. However, this proportion decreased by 7.9 percentage points compared to 2010 levels. Renewable energy's share rose from 2.1 % in 2010 to 11.9 % in 2023 – 9.8 percentage point increase – becoming the key driver behind the structural optimization of global energy trade [28].

Within the fossil energy trade, the structure is also undergoing continuous adjustments. First, crude oil trade remains the core of fossil energy trade, accounting for over 50 % of the total volume, but its share has shown a slow downward trend, declining from 55.2 % in 2010 to 49.7 % in 2023. Second, the share of natural gas trade continues to rise, increasing from 20.3 % in 2010 to 31.4 % in 2023, making it the fastest-growing category in fossil energy trade, primarily due to the cleanliness and efficiency of natural gas, as well as advancements in global natural gas extraction technology and improvements in transportation infrastructure. Third, the share of coal trade has shown a downward trend, decreasing from 24.5 % in 2010 to 18.9 % in 2023, mainly influenced by global low-carbon transition and the rapid development of coal alternatives, leading to slower growth in global coal demand and sluggish expansion in coal trade volume [3]. In 2024, this trend intensified further, with the share of coal trade declining by 1.2 percentage points year-on-year, the share of natural gas trade rising by 0.8 percentage points, and the share of crude oil trade declining by 0.3 percentage points, primarily affected by factors such as China's reduced coal imports and the rebound in global natural gas demand (figure 1.4).

Within the renewable energy trade, photovoltaic modules and wind power equipment are the main categories, accounting for over 80 % of the total renewable energy trade volume. In 2023, the global trade volume of photovoltaic modules reached 1.5

billion tons of standard coal equivalent, accounting for 60.0 % of the total renewable energy trade; the trade volume of wind power equipment reached 500 million tons of standard coal equivalent, accounting for 20.0 %; and the trade volume of other renewable energy sources such as biomass energy and hydrogen energy reached 500 million tons of standard coal equivalent, accounting for 20.0 %.



Figure 1.4 – Global Energy Trade Year on year Growth Rate, 2010–2023 [18]

With advancements in renewable energy technologies and cost reductions, the global trade volumes of photovoltaic modules and wind power equipment have continued to grow rapidly [35]. From 2010 to 2023, the annual average growth rate of global photovoltaic module trade volume reached 15.6 %, while that of wind power equipment trade volume reached 10.8 %, becoming the core driving force behind the growth of renewable energy trade. Additionally, emerging renewable energy trade sectors such as hydrogen energy and energy storage are also rising rapidly. Although currently small in scale, they hold tremendous potential and have become a new direction for optimizing the global energy trade structure (figure 1.5). China holds a significant position in global renewable energy trade [47].

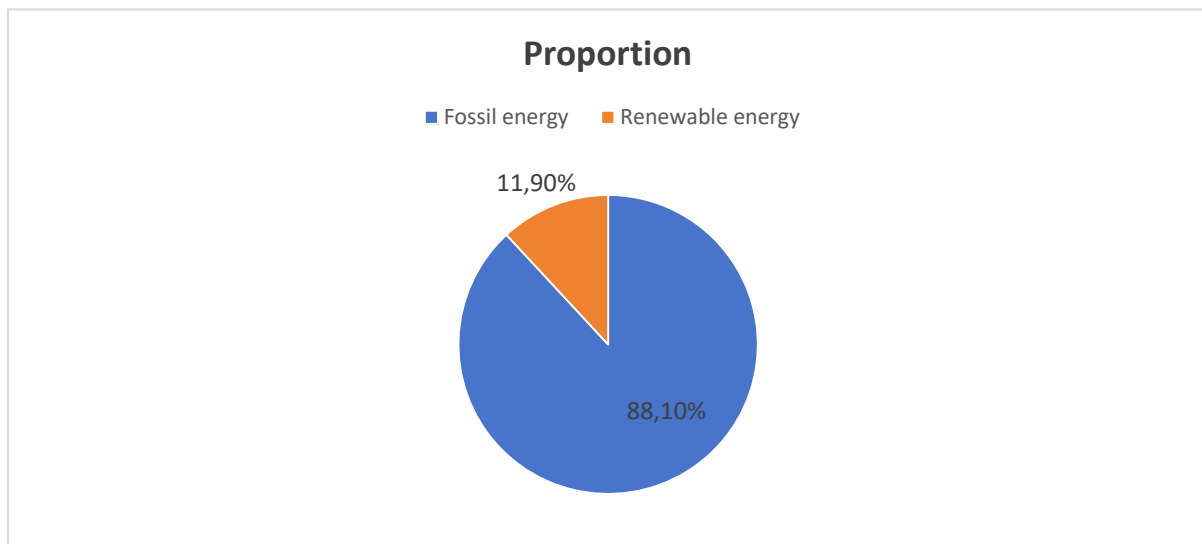


Figure – 1.5 The proportion of fossil energy and renewable energy [10; 19]

From a regional perspective, global energy trade exhibits distinct characteristics of clear regional specialization and pronounced multi-polar trends. Firstly, energy export regions demonstrate relative concentration, primarily concentrated in areas with abundant energy resources such as the Middle East, Central Asia, North America, and Africa. In 2023, the Middle East accounted for 6.5 billion tons of standard coal equivalent in energy exports, representing 35.1 % of global total, mainly exporting crude oil and natural gas. Central Asia contributed 2.5 billion tons of standard coal equivalent (13.5 %), primarily exporting natural gas and crude oil. North America recorded 3 billion tons of standard coal equivalent (16.2 %), mainly exporting crude oil, natural gas, and coal. Africa accounted for 2 billion tons of standard coal equivalent (10.8 %), focusing on crude oil and coal exports. Secondly, energy import regions show concentrated distribution, predominantly located in energy-demand-driven areas like Asia and Europe. In 2023, Asia imported 8 billion tons of standard coal equivalent (43.2 % of global total), mainly importing crude oil, natural gas, and coal. Europe imported 4 billion tons of standard coal equivalent (21.6 %), primarily natural gas and crude oil. North America imported 2.5 billion tons of standard coal equivalent (13.5 %), mainly crude oil and natural gas. Third, inter-regional energy trade links are becoming increasingly close, with a pronounced trend toward multi-polarity. The traditional unidirectional trade model of energy exporting countries – energy

importing countries is gradually shifting toward a multi-regional, multi-category, two-way flow trade model [58]. Table 1.1 shows share of global energy exports by region.

Table 1.1 – Share of global energy exports by region [10; 18]

Export Area	Export Volume (billion tons of standard coal equivalent)	Proportion of Global Energy Exports	Main Exported Energy Categories
Middle East	6.5	35.10 %	Crude oil, Natural gas
North America	3	16.20 %	Crude oil, Natural gas, Coal
Central Asia	2.5	13.50 %	Natural gas, Crude oil
Africa	2	10.80 %	Crude oil, Coal

The flow direction of global energy trade is primarily influenced by factors such as energy resource endowment, energy demand distribution, geopolitical dynamics, and transportation infrastructure. It generally exhibits the core characteristic of flowing from energy-rich regions to energy-demand-intensive regions, while continuously evolving with adjustments in the global energy landscape [17].

From the perspective of crude oil trade flows, global crude oil trade primarily originates from production regions such as the Middle East, Central Asia, Africa, and North America, and flows to consumption regions like Asia, Europe, and North America. Specifically, crude oil from the Middle East is mainly exported to Asia. In 2023, over 70 % of Middle Eastern crude oil exports were directed to Asian countries such as China, India, Japan, and South Korea, with the remainder exported to regions like Europe and North America. Crude oil from Central Asia is primarily exported to countries such as China and Russia, with some transported via pipelines to Europe [66]. Crude oil from Africa is mainly exported to Europe and Asia, with West African crude oil primarily destined for Europe and North African crude oil for Asia. Crude oil from North America is mainly exported to Europe and Asia, with the United States becoming a key global crude oil exporter, primarily supplying Europe and China. Notably, China's oil imports declined by 1.9 % in 2024, leading to certain adjustments in Middle Eastern crude oil export flows,

with some crude oil redirected to regions like India and Europe. However, Asia remains the core market for Middle Eastern crude oil exports [58].

From the perspective of natural gas trade flows, global natural gas trade is mainly divided into pipeline natural gas trade and liquefied natural gas (LNG) trade, with flows exhibiting characteristics of regional concentration and increased cross-regional mobility. Pipeline natural gas trade is primarily concentrated within regions, such as within Europe, Asia, and North America. In 2023, the total global pipeline natural gas trade reached 3.5 billion tons of standard coal equivalent, with intra-European pipeline natural gas trade accounting for 40 %, intra-Asian trade for 30 %, and intra-North American trade for 20 %. LNG trade, on the other hand, demonstrates cross-regional mobility, primarily flowing from LNG-producing countries such as Qatar, Australia, the United States, and Russia to LNG-consuming regions like Asia and Europe. In 2023, global LNG trade totaled 2.3 billion tons of standard coal equivalent, with Asia accounting for over 70 % of global LNG imports and Europe for over 20 %. In 2024, China's natural gas imports declined by 6.2 % year-on-year, further driving adjustments in global LNG trade flows, with some LNG resources shifting to regions like Europe and India [58].

From the perspective of coal trade flows, global coal trade primarily originates from coal-producing countries such as Australia, Indonesia, and Russia, and flows to Asian nations like China, India, Japan, and South Korea, as well as some European countries. In 2023, the total volume of global coal trade reached 3.5 billion tons of standard coal, with Asia accounting for over 80 % of global coal imports and Europe making up about 10 %. In recent years, influenced by global low-carbon transitions and the rapid development of coal alternatives, the direction of global coal trade has undergone certain adjustments. Europe's coal imports have continued to decline, while Asia's coal imports have remained stable, though internal structural changes have occurred. China's coal imports have shown a downward trend, whereas India's coal imports have exhibited an upward trend. In the first three quarters of 2024, China's coal imports decreased by 11.1 % year-on-year, primarily due to the release of domestic coal production capacity and clean energy

upgrades, which further drove the adjustment of global coal trade flows. Coal-producing countries such as Indonesia and Australia have increased exports to India [5].

From the perspective of renewable energy trade flows, global renewable energy trade primarily originates from countries and regions with advanced new energy industries such as China, the EU, and the US, and flows to various parts of the world, exhibiting the characteristics of multi-regional and bidirectional flows. In 2023, China was the world's largest exporter of photovoltaic modules and wind power equipment, accounting for over 70 % of global photovoltaic module exports and over 40 % of global wind power equipment exports, mainly exported to regions such as Europe, Asia, and North America. The EU and the US are also significant exporters of renewable energy products, primarily exporting high-value-added new energy technologies and equipment. Meanwhile, countries and regions such as China, the EU, and the US also import certain renewable energy products, such as high-end photovoltaic modules and wind power equipment components, forming a bidirectional trade pattern. With the advancement of global energy transition, the flow of renewable energy trade will become more diversified, and emerging economies will become important growth poles for renewable energy trade [53].

Overall, global energy trade flows exhibit a pattern where fossil fuels are predominantly transported uni-directionally between regions, while renewable energy demonstrates bidirectional flows across multiple regions. Influenced by factors such as geopolitical dynamics, energy transition, and shifting energy demand patterns, the direction of global energy trade continues to evolve, with increasingly evident trends toward multi-polarity and diversification.

1.2 Restructuring effects of global energy transition on trade patterns

The global energy transition refers to the transformation of the world's energy system from fossil fuel dominance to renewable and clean energy leadership. Its core principles encompass cleaner energy, low-carbon development, diversified sources, and smart systems, aiming to address climate change, ensure energy security, and promote

sustainable economic growth. Three key factors have driven this transition. First, escalating climate change – with rising global temperatures and frequent extreme weather events – has made carbon reduction and low-carbon development a global consensus. The signing and implementation of the Paris Agreement have accelerated energy transitions worldwide, reducing fossil fuel consumption and increasing renewable energy adoption. Second, growing energy security concerns, including the non-renewable nature of fossil fuels and geopolitical conflicts disrupting supply chains, have highlighted the importance of diversified and cleaner energy sources. Countries are rapidly expanding renewable energy development to reduce dependence on fossil fuels. Third, technological advancements – including breakthroughs in renewable energy technologies, energy storage systems, and smart grid solutions – have lowered operational costs and enhanced competitiveness, providing crucial technical support for energy transition [60]. Table 1.2 shows annual breakdown of China's energy trade import and export.

Table 1.2 – Annual breakdown of China's energy trade import and export total (2018–2023) [10]

Year	Total imports (billion USD)	Total exports (billion USD)	Total imports and exports (billion USD)	Year-on-year growth rate
2018	38500	3600	42100	8.2
2019	39800	3700	43500	3.3
2020	37600	3600	41200	-5.3
2021	44200	4700	48900	18.7
2022	47500	4800	52300	6.9
2023	50100	5500	55600	6.3

The global energy transition has now entered an accelerated phase, demonstrating several notable development trends.

Firstly, renewable energy has become the core driving force for energy growth. In recent years, the scale of global renewable energy development and utilization has continued to expand, with its share in global electricity generation steadily increasing.

According to data from the IEA's Global Renewable Energy Outlook (2024), in 2023, renewable energy accounted for 30 % of global electricity generation, an increase of 15 percentage points compared to 2010. It is projected that by 2030, this proportion will rise to over 40 %, and by 2050, it will exceed 70 %, making renewable energy the dominant force in global energy supply. Among these, photovoltaic and wind power are the core drivers of renewable energy growth. In 2023, photovoltaic and wind power generation accounted for over 70 % of total renewable energy output, and it is expected that their growth rates will remain above 10 % in the coming years. China plays a significant role in global renewable energy development. Over the past decade, China's annual new installed capacity in renewable energy has accounted for more than 40 % of the global total, and its contribution to the rise in global non-fossil energy consumption has reached 45.2 % [28].

Secondly, while the share of fossil fuel consumption continues to decline, they will remain dominant for the foreseeable future. Despite accelerated global energy transition efforts, fossil fuels still constitute the primary energy source, maintaining high consumption levels particularly in industrial and transportation sectors where substitution requires prolonged adaptation. According to BP Statistical Review of World Energy (2024), fossil fuels accounted for 79.3 % of global energy consumption in 2023, projected to drop to around 70 % by 2030 and below 50 % by 2050. The internal structure of fossil fuels will undergo continuous optimization: coal consumption is rapidly declining, natural gas serves as a transitional energy source due to its clean characteristics with stable and slightly increasing share, while crude oil consumption decreases gradually alongside electrification advancements in transportation. Additionally, technologies like carbon capture, utilization and storage (CCUS) will drive low-carbon transformation of fossil fuels, extending their operational lifespan within energy systems [47].

Thirdly, energy technology innovation has emerged as the core driving force for industrial transformation. The global energy transition heavily relies on technological breakthroughs, with key research priorities including: enhancing efficiency and reducing costs in photovoltaic and wind power systems; scaling up energy storage technologies with improved safety standards; advancing hydrogen energy industrialization; and developing

intelligent grid systems featuring smart connectivity. In 2023, global photovoltaic module conversion efficiency surpassed 26 %, while wind turbine capacity continued to increase alongside breakthroughs in offshore wind technology. Lithium battery storage costs dropped by over 85 % compared to 2010 levels. Concurrently, nations are ramping up investments in energy R&D, with collaborative innovation models between governments and enterprises becoming mainstream. Cross-border technological cooperation and knowledge exchange have intensified, making patent portfolio strategies a critical battleground in the renewable energy industry competition [23].

Fourthly, energy marketization and policy coordination have seen continuous improvement. To facilitate energy transition, countries have introduced diversified policy measures including renewable energy subsidies, carbon pricing mechanisms, and total energy consumption controls, with enhanced policy precision and synergy. Concurrently, energy market reforms continue to advance, with renewable energy integration, interconnection of power markets, and market-based pricing mechanisms for energy commodities emerging as key trends. The implementation of the EU Carbon Border Adjustment Mechanism (CBAM) signifies a closer alignment between global energy trade and carbon reduction policies, strengthening low-carbon constraints on energy trade and accelerating countries' energy structure adjustments [40].

The accelerated global energy transition has fundamentally reshaped the product structure of international energy trade. Traditional fossil fuel trade is gradually losing its dominant position, while renewable energy trade has emerged as a new growth engine. The energy trade portfolio is transitioning from a single fossil fuel-dominated model to a coordinated development of fossil fuels and renewable energy, as evidenced by the following aspects.

Firstly, the internal structure of fossil energy trade continues to optimize, with coal trade contracting while natural gas trade has become the growth driver. Influenced by global low-carbon transition and rapid development of coal alternatives, worldwide coal demand remains sluggish, resulting in stagnant growth in coal trade volume and a declining share in global energy trade. From 2010 to 2023, the global coal trade share

decreased from 24.5 % to 16.7 %, a trend expected to persist until 2030 when it is projected to fall below 10 %. In contrast, natural gas, as a clean fossil energy source, has emerged as a transitional fuel for energy transitions worldwide. Global natural gas demand continues to grow alongside expanding trade volumes, with its share rising from 20.3 % to 27.6 % during the same period. Liquefied natural gas (LNG) trade has become the core growth driver due to transportation flexibility, accounting for 41.4 % of global LNG trade in 2023 – a 12-percentage-point increase from 2010 levels. Although crude oil trade remains a cornerstone of global energy trade, its share is gradually declining amid shifting demand patterns shifting from refined oil consumption to chemical feed-stock usage, driving product segmentation in crude oil trade [36].

Secondly, the renewable energy trade has experienced rapid growth, emerging as a new growth driver in global energy trade. With advancements in renewable energy technologies and cost reductions, international trade volumes for new energy products such as photovoltaic modules and wind power equipment continue to rise. From 2010 to 2023, the global renewable energy trade saw an average annual growth rate of 12.3 %, significantly outpacing the 2.1 % annual growth rate of fossil fuel trade. In 2023, global renewable energy trade reached 2.5 billion tons of standard coal equivalent, accounting for 11.9 % of total global energy trade, with projections indicating this share will exceed 25 % by 2030. Photovoltaic modules and wind power equipment dominate the renewable energy trade, collectively representing 80 % of total trade volume in 2023. High-value-added components like new energy parts and energy storage systems are experiencing rapid growth, emerging as key segments within the renewable energy trade [55].

Thirdly, energy trade categories are expanding into integrated energy products, with energy service trade emerging as a new complement. The global energy transition has not only reshaped the trade structure of physical energy products but also extended energy trade into service sectors. The scale of energy service trade – including energy technical services, energy engineering services, and energy management services – continues to grow. For instance, services such as design, construction, and operation maintenance for new energy power plants, carbon accounting and trading services, and smart grid technical

consulting have become new components of international energy trade. Meanwhile, the integration of energy products with digital technologies is becoming increasingly tight, driving the rise of integrated energy products like smart photovoltaic, smart wind power, and digital energy storage systems. This trend is promoting the diversification and high-end development of energy trade categories.

The global energy transition has not only transformed the product mix of international energy trade but also profoundly reshaped its regional dynamics. The traditional regional division of labor in energy trade has been disrupted, while new energy trade hubs have emerged. Inter-regional energy trade connections have shifted from one-way flow of fossil fuels to two-way flow of renewable energy, as evidenced by the following aspects.

Firstly, traditional energy exporters are accelerating energy structure transformation and diversifying their trade roles. Traditional fossil fuel exporters such as the Middle East, Central Asia, and Russia, impacted by declining global fossil fuel demand, are rapidly developing renewable energy resources to diversify their energy export portfolios. For instance, Saudi Arabia has launched its Vision 2030 initiative, aiming to achieve 58.7GW of renewable energy capacity by 2030 and establish itself as a regional producer and exporter of new energy products. Russia is increasing investments in wind and solar power industries while promoting coordinated development between natural gas trade and renewable energy trade. Middle Eastern oil-producing nations are also transitioning energy trade models from crude oil exports to comprehensive energy supply through investments in renewable technologies and construction of new energy power plants. Concurrently, intensified competition among traditional fossil fuel exporters has prompted market players to optimize crude oil and natural gas pricing mechanisms and cooperation frameworks to maintain market share [36].

Secondly, emerging economies have become the core force in renewable energy trade, with their trade status rising. Emerging economies such as China, India, and Brazil have been steadily enhancing their position in global renewable energy trade through the rapid development of their new energy industries. China has become the world's largest

exporter of photovoltaic modules and wind power equipment, accounting for over 70 % of global photovoltaic module exports and over 40 % of global wind power equipment exports in 2023, making it a key supplier in global renewable energy trade. India has expanded its photovoltaic industry layout, becoming a major producer and importer of photovoltaic modules while promoting localized production and export of wind power equipment. Brazil, leveraging its advantages in biomass energy and hydro-power resources, has become a core region for renewable energy trade in South America. The rise of emerging economies has disrupted the dominance of developed countries in global energy trade, driving the regional pattern of global energy trade toward multi-polarity [58].

Third, developed countries are accelerating their new energy trade layout, focusing on high-value-added sectors. Developed nations such as the EU, the US, and Japan leverage their advantages in new energy technologies and high-end component R&D to concentrate on high-value-added renewable energy trade areas, including core new energy components, energy storage technologies, and hydrogen equipment. They also maintain their high-end position in global new energy trade by establishing technical barriers and intellectual property barriers. For example, the EU promotes domestic new energy industry development through the Net Zero Industrial Act, reducing import dependence on China's photovoltaic and wind power equipment. The US introduced the Inflation Reduction Act to provide subsidies for domestic new energy industries, fostering localized production and export of new energy products. Meanwhile, new energy trade cooperation among developed countries is becoming increasingly close, with regional trade agreements facilitating the free movement of new energy products within their territories [40].

Fourth, regional energy trade communities are gradually taking shape, with trade localization trends becoming increasingly prominent. To mitigate energy supply chain risks and accelerate energy transition, countries are strengthening regional energy trade cooperation and establishing integrated energy trade frameworks. For instance, the European Union has enhanced intra-regional energy collaboration through promoting electricity market integration and developing regional natural gas storage systems. ASEAN launched the ASEAN Energy Cooperation Action Plan (2021–2025) to facilitate

renewable energy trade and power grid interconnection. The Shanghai Cooperation Organization (SCO) has intensified energy cooperation among member states, advancing crude oil and natural gas pipeline projects while expanding trade in new energy products. The emergence of these regional energy trade communities has significantly accelerated localization trends in energy trade, with intra-regional trade volumes steadily increasing and becoming a defining feature of global energy trade patterns [30].

Restructuring of Energy Trade Rules in the Context of Global Energy Transition

The advancement of global energy transition has intensified low-carbon constraints on international energy trade. Traditional energy trade rules can no longer adapt to emerging trends, driving a restructuring of global energy trade frameworks toward decarbonization, greening, and diversification. This transformation is specifically manifested in the following aspects.

Firstly, carbon emission reduction has become a core element of energy trade regulations, with low-carbon trade barriers gradually taking shape. As global consensus on carbon reduction continues to strengthen, emission reduction targets have emerged as key benchmarks for measuring energy product trade. The implementation of policies such as the EU Carbon Border Adjustment Mechanism (CBAM) and the U.S. Clean Energy Standard signifies an increasingly close integration between energy trade and carbon reduction policies. These policies require imported high-carbon energy products to pay carbon tariffs or meet specific low-carbon standards, effectively creating low-carbon trade barriers. This drives countries to accelerate the low-carbon transformation of energy products and reduce carbon emission intensity in energy trade. Meanwhile, the trend toward interconnected global carbon trading markets is becoming more pronounced, with carbon allowances emerging as essential complementary products for energy trade, fostering the convergence of energy trade rules and carbon trading regulations [16].

Secondly, the formulation of renewable energy trade rules has become a central issue in global energy governance. With the rapid expansion of renewable energy trade, the lack of standardized regulations has emerged as a critical constraint on its development. Establishing unified and regulated trade frameworks for renewable energy has thus

become a pivotal focus in global energy governance. Countries are actively advancing tariff reductions, technical standard harmonization, and intellectual property protection measures for renewable energy products through multilateral and bilateral trade agreements. For instance, the Regional Comprehensive Economic Partnership (RCEP) implements tariff exemptions for photovoltaic modules and wind power equipment, facilitating trade liberalization within the region. The WTO's Clean Energy Trade Initiative further promotes global trade liberalization and regulatory alignment for new energy products. Concurrently, international coordination on technical standards and product certification systems has become a key component in shaping renewable energy trade regulations [47].

Third, the entities formulating energy trade rules have become more diversified, with developing countries gradually gaining more influence. Traditional international energy trade rules were primarily dominated by developed countries, making it difficult to reflect the interests of developing nations. As emerging economies have risen in global energy trade, developing countries have shown increasing willingness and capacity to participate in shaping global energy trade rules, driving the diversification of rule-making entities. For instance, developing countries such as China, India, and Brazil have proposed energy trade rules aligned with their interests at multilateral platforms like the G20 and BRICS, promoting a more equitable, just, and inclusive direction for global energy trade rules. Emerging multilateral platforms like the Shanghai Cooperation Organization (SCO) and BRICS have become key vehicles for energy trade rule formulation, complementing traditional bodies like the International Energy Agency (IEA) and the Organization of the Petroleum Exporting Countries (OPEC), thereby advancing the restructuring of the global energy governance system [59].

Fourth, the resilience of energy supply chains has become an important component of energy trade rules. Influenced by factors such as geopolitical conflicts and the COVID-19 pandemic, energy supply chain security has become a core concern for countries, and the resilience of energy supply chains has been incorporated into the formulation of energy trade rules. In energy trade agreements, countries have increasingly included clauses on

supply chain security, emergency safeguards, and diversified supply to promote the diversification of energy trade partners and reduce dependence on single supply channels. For example, the EU requires the establishment of an energy supply emergency coordination mechanism in its agreements with energy trade partners; China's energy cooperation agreement with countries along the Belt and Road emphasizes the inter connectivity of infrastructure such as energy pipelines and ports to enhance supply chain resilience. Meanwhile, the integration of energy trade rules with infrastructure construction and logistics transportation rules is becoming increasingly close, driving the integrated development of the global energy supply chain

1.3 New characteristics and trends in global energy geopolitics

Since the dawn of the 21st century, the global geopolitical landscape has undergone profound transformations. The strategic significance of energy has become increasingly prominent, with geopolitical factors emerging as one of the key variables influencing the international energy trade landscape.

Traditional global energy geopolitical competition has primarily centered on fossil fuels such as oil and natural gas, with key players being conventional energy exporters and importers including OPEC member states, the United States, and European nations. Currently, the landscape of global energy geopolitics has become increasingly diversified, encompassing not only traditional energy exporters and importers but also countries with advanced renewable energy industries and emerging economies. Energy competition among major powers has emerged as the central focus of this strategic rivalry.

On one hand, major countries and economies such as the United States, China, Russia, and the European Union have become the core players in energy geopolitical competition, engaging in comprehensive rivalry over energy resources, energy technologies, energy trade rules, and global energy governance discourse. Leveraging the energy self-sufficiency capabilities brought by the shale gas revolution, the United States has advanced its energy independence strategy while expanding its influence in the global

energy landscape through strengthened energy cooperation with the Middle East, Europe, and the Asia-Pacific region. Russia, relying on its abundant fossil fuel resources, has employed energy as a geopolitical tool to enhance energy cooperation with emerging economies like China and India, while also engaging in energy competition with the European Union. The European Union has reduced its dependence on external fossil fuels by promoting energy transition and establishing a regional energy trade community, thereby strengthening its voice in global energy governance. As the world's largest energy importer and exporter of new energy products, China has become a key participant in global energy geopolitical competition, driving energy import diversification and the globalization of new energy trade to elevate its status in global energy governance [60].

On the other hand, emerging economies and traditional energy exporters are increasingly competing for strategic influence, emerging as key players in global energy geopolitics. Countries like India and Brazil, driven by rising energy demand and advancements in renewable energy sectors, have strengthened their positions in global energy trade. They are actively pursuing independent energy strategies to diversify energy imports and expand renewable energy trade. Meanwhile, traditional energy exporters such as those in the Middle East and Central Asia are accelerating energy structure transitions to maintain their global influence. These nations are diversifying energy exports while enhancing energy cooperation with emerging economies, engaging in strategic competition with developed countries.

Table 1.3 – Major Energy Trade Partners of China (2023) [10; 18]

Cooperative Partner	Total trade (billion USD)	Import value (billion USD)	Export value (billion USD)	Trade share (%)
Russia	8900	7800	1100	16
Saudi Arabia	7200	6800	400	12.9
EU(European Union)	6500	4200	2300	11.7
America	5800	3500	2300	10.4
India	4100	1800	2300	7.4

Traditional global energy geopolitical competition primarily centered on the rivalry for fossil fuel resources, control of trade routes, and competition for pricing power. With the advancement of global energy transition, the scope of energy geopolitical competition continues to expand, with new energy emerging as a new focal point. Competition over new energy resources, technologies, industries, and trade regulations has become increasingly intense.

In terms of new energy resources, key minerals such as lithium, cobalt, nickel, and rare earth have become the focus of competition among countries. These minerals serve as core raw materials for industries like photovoltaic, wind power, energy storage, and new energy vehicles, and their resource distribution and supply patterns directly impact the development of new energy industries in various countries. Currently, the resource distribution of key new energy minerals is highly concentrated: lithium resources are mainly concentrated in Chile, Australia, and Argentina; cobalt resources are primarily found in the Democratic Republic of the Congo; and rare earth resources are predominantly located in China. Countries are intensifying their competition for key new energy mineral resources through investments, cooperation, and development efforts to ensure resource supply security [65].

In terms of new energy technologies, core technologies such as photovoltaics, wind power, energy storage, and hydrogen energy have become the key areas of competition among countries. Countries are increasing investment in new energy technology research and development to promote technological breakthroughs and industrialization, while maintaining their technological advantages through measures like intellectual property protection and technological blockades. For example, developed countries leverage their strengths in high-end new energy technologies and core component R&D to set technical barriers and restrict technology transfer to developing countries. Emerging economies like China, through independent R&D and technological innovation, have established advantages in mid-to-low-end technology sectors such as photovoltaics and wind power, while accelerating the development of high-end technologies to drive technological upgrades.

In the field of new energy industries, countries have introduced industrial policies to promote the development of domestic new energy industries and enhance industrial competitiveness. The new energy industry has become a key lever for economic development and geopolitical competition among nations. For example, the United States enacted the Inflation Reduction Act, providing substantial subsidies to domestic new energy industries to boost localized production of photovoltaic, wind power, and new energy vehicles. The European Union launched the Net Zero Industry Act, setting production capacity targets for domestic new energy industries to reduce dependence on imported new energy products. China introduced the New Energy Industry Development Plan (2021–2035) to promote large-scale and high-end development of the new energy industry and enhance global competitiveness.

In the realm of new energy trade regulations, nations engage in strategic negotiations regarding tariffs on renewable energy products, technical standards, intellectual property protection, and carbon emission reduction criteria, driving the establishment of trade rules that align with their respective interests. Developed countries seek to maintain their dominant position in global new energy trade by imposing low-carbon trade barriers and technological restrictions, while developing countries advocate for trade liberalization and facilitation, urging developed nations to relax technology transfer limitations to promote equitable and inclusive global trade frameworks [55].

Currently, the global energy geopolitical competition exhibits diversified characteristics, no longer limited to traditional political and military means. Economic, technological, diplomatic, and rule-making approaches have become crucial strategies in this arena. The coexistence of cooperation and competition during the process has emerged as a defining feature of global energy geopolitics.

In terms of competition, countries engage in energy sector rivalry through measures such as trade barriers, technological blockades, and resource monopolies. For instance, developed nations impose anti-dumping and countervailing duties on China's photovoltaic and wind power equipment, while introducing technical standards to restrict imports. Traditional energy exporters compete in fossil fuel trade by adjusting production volumes

and pricing mechanisms. Countries also vie for control over critical mineral resources for new energy development, leading to resource grabs and monopolies. Meanwhile, major powers compete for influence in global energy governance, striving to dominate the formulation of energy trade rules and carbon emission reduction regulations [56].

In terms of cooperation, facing common challenges such as global climate change and energy supply chain security, countries have strengthened multilateral and bilateral cooperation in the energy sector to promote the sharing of energy resources, technologies, and markets. For example, China has enhanced energy cooperation with Belt and Road countries, advancing the construction of crude oil and natural gas pipelines as well as trade in new energy products; the EU and the US have strengthened cooperation in new energy technologies, promoting research, development, and industrialization of hydrogen energy and energy storage technologies; the BRICS countries established the New Development Bank to provide financial support for energy infrastructure construction and new energy industry development in member states; the Shanghai Cooperation Organization has strengthened energy cooperation among member states to build a regional energy trade community. Meanwhile, countries are increasingly collaborating in areas such as global carbon reduction and energy transition, signing multilateral agreements to promote sustainable global energy development.

Traditional global energy geopolitical competition has primarily centered on regions such as the Middle East, Europe, and North America. The Middle East, endowed with abundant oil resources, has become a powder keg of global energy geopolitics, while Europe and North America engage in strategic rivalries over fossil fuel trade and governance influence. With the global economic center of gravity shifting toward the Asia-Pacific region, the area now sees sustained growth in energy demand and rapid development of renewable energy industries, emerging as the core battleground for global energy geopolitics. This shift is simultaneously reshaping the existing power dynamics among traditional regions like the Middle East, Europe, and North America.

The Asia-Pacific region has become the core area of global energy geopolitical competition, primarily due to the following factors: First, the Asia-Pacific region is the

world's largest energy import region. Countries such as China, India, Japan, and South Korea have seen continuous growth in energy demand, which increasingly impacts global energy trade and makes it a key market contested by nations. Second, the Asia-Pacific region is the core area for the development of the global new energy industry. Countries like China, Japan, and South Korea possess strong industrial competitiveness in fields such as photovoltaic, wind power, energy storage, and new energy vehicles, leading to intensifying competition over new energy industries, technologies, and trade. Third, the geopolitical landscape in the Asia-Pacific region is complex, with escalating competition among major powers. Energy has become a crucial tool in this rivalry. For example, the United States has strengthened energy cooperation with Asia-Pacific countries through its Indo-Pacific Strategy, aiming to curb China's energy influence in the region. In response, China has enhanced energy connectivity with Asia-Pacific countries through the Belt and Road Initiative, promoting regional energy cooperation [4].

The energy geopolitical landscape in the Middle East has undergone adjustments, shifting from the traditional US-EU rivalry to a more diversified competition. To reduce dependence on US and European markets, Middle Eastern oil-producing countries have strengthened energy cooperation with emerging economies in the Asia-Pacific region, such as China and India, promoting diversification of energy export markets. Meanwhile, these countries are accelerating energy structure transformation, fostering the development of new energy industries, reducing reliance on fossil fuels, and enhancing their position in the global energy landscape. Additionally, internal conflicts in the Middle East and interventions by major powers have intensified energy geopolitical competition in the region, posing challenges to the stability of energy supply chains.

Europe is accelerating energy import diversification to reduce dependence on Russian fossil fuels while strengthening energy cooperation with the United States, the Middle East, and Africa, promoting diversified import channels for natural gas and crude oil. Additionally, Europe is speeding up its energy transition by advancing renewable energy development and decreasing reliance on external energy sources, positioning itself as a global pioneer in energy transformation. However, Europe's energy transition faces

challenges such as high costs and slow progress, with energy supply security remaining a critical issue that has become the core contradiction in Europe's energy geopolitical dynamics [12].

North America's strategic position in energy geopolitics continues to rise. Leveraging the energy self-sufficiency achieved through the shale gas revolution, the United States has transitioned from an energy importer to an exporter, deepening energy cooperation with Europe and the Asia-Pacific region while expanding its export markets. Simultaneously, it advances its energy independence strategy, utilizing energy as a geopolitical tool to strengthen its influence in the global energy landscape. Canada, capitalizing on its abundant oil and natural gas resources along with renewable energy potential, has intensified energy collaboration with the U.S. and Asia-Pacific nations, emerging as a key player in North America's energy geopolitical dynamics.

Chapter 2 Analysis of the current situation of China's international energy trade

2.1 Structure and scale evolution of China's international energy trade

As the world's largest energy consumer, importer, and exporter of new energy products, China's international energy trade development is deeply integrated with the transformation of the global energy landscape. The trade scale continues to expand, the structure keeps improving, and the layout of source locations and trade routes is gradually perfected. Its role has shifted from a single fossil energy importer to a two-way participant in fossil energy imports and new energy product exports, with its influence in the global energy trade system steadily increasing. This chapter comprehensively analyzes the current status of China's international energy trade development from two aspects: category structure and scale evolution, as well as the roles of source locations and trade route layouts, based on the latest data from 2024.

The category structure of China's international energy trade is dominated by fossil fuel imports, with new energy product exports serving as the core growth point. In recent years, with the advancement of domestic energy transition and the implementation of the dual carbon goals, the trade structure has continued to optimize. The internal structure of fossil fuel imports has been continuously adjusted, while the export scale of new energy products has grown rapidly. The trade scale has shifted from quantity expansion to quality improvement. Characteristics such as the first decline in oil imports and differentiated declines in coal and natural gas imports observed in 2024 have become important signals for the adjustment of China's energy trade structure.

1 Traditional fossil fuel trade: scale stabilizes with structural optimization.

Fossil fuels remain the core category in China's international energy trade, including crude oil, natural gas, and coal. In recent years, the overall trade volume has stabilized, with slower growth in import volumes and continuous optimization of internal structures. The demand structure has shifted from energy consumption to industrial production.

Meanwhile, the release of domestic production capacity and clean transformation have led to a decline in coal imports, while renewable energy substitution has prompted short-term adjustments in natural gas imports.

Crude oil: Import volume shows minor adjustments, with demand structure tilting toward chemical feed-stocks.

China is the world's largest crude oil importer, with its import volume maintaining long-term growth. In 2023, imports reached 560 million tons, with an external dependence exceeding 70 %. In 2024, China experienced its first substantial decline since becoming a major global crude oil buyer in 2004, with imports dropping to 553 million tons, a year-on-year decrease of 1.9 % and a daily reduction of 240,000 barrels. This change is not a short-term market fluctuation but a significant signal of China's strategic shift from oil dependence to energy sovereignty.

From the perspective of demand structure, the demand structure for China's crude oil imports has undergone fundamental changes, with the proportion of refined oil consumption continuously declining and the proportion of chemical raw material consumption steadily increasing, becoming the core factor driving the adjustment of crude oil import structure. With the rapid advancement of electrification in the domestic transportation sector, the demand growth rate for refined oil products such as gasoline and diesel has slowed down. In 2023, the share of domestic refined oil consumption in crude oil processing volume dropped below 55 %, while the demand for chemical products such as ethylene and propylene continued to grow, raising the proportion of chemical raw material consumption to over 45 %, pushing crude oil imports toward varieties with stronger chemical raw material attributes. Meanwhile, the structural adjustment of the domestic refining industry and the transformation of refineries toward integrated chemical production have also contributed to the optimization of crude oil demand structure.

In terms of trade methods, China's crude oil imports are primarily conducted through general trade, with general trade accounting for over 85 % of imports in 2023. Meanwhile, emerging trade methods such as cross-border e-commerce and bonded trade are gradually gaining momentum, serving as supplements to crude oil trade. Regarding

pricing methods, China's crude oil imports mainly refer to international crude oil benchmarks such as Brent, WTI, and Dubai. In recent years, China has accelerated the development of its crude oil futures market, with the trading volume of crude oil futures at the Shanghai International Energy Exchange (INE) continuing to grow, thereby enhancing its influence on international crude oil pricing (figure 2.1).

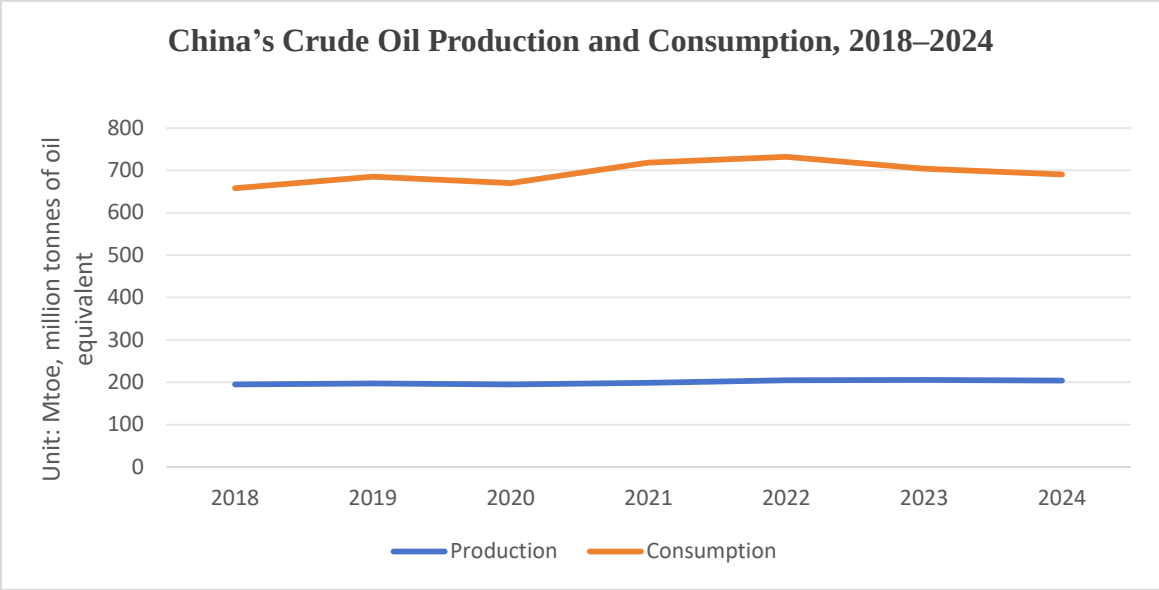


Figure 2.1 – China’s crude oil production and consumption [10]

Natural gas: short-term adjustment in import scale, with a diversified import pattern gradually taking shape.

China is the world's second-largest natural gas importer, with its import volume continuing to grow. In 2023, the import volume was approximately 110 million tons, with an external dependence rate approaching 45 %. In the first three quarters of 2024, the import volume decreased by 6.2 % year-on-year, showing a short-term adjustment. This was mainly due to the substitution effect of domestic renewable energy on natural gas and the release of domestic natural gas production capacity [14].

In terms of import categories, China's natural gas imports include two major types: pipeline natural gas (PNG) and liquefied natural gas (LNG). In recent years, the proportion of LNG imports has continued to rise, gradually forming a diversified import pattern. In 2023, China's LNG imports accounted for 58 % of total natural gas imports, an increase of

30 percentage points compared to 2010, mainly due to the flexibility of LNG transportation and the improvement of domestic infrastructure such as LNG receiving terminals. Pipeline natural gas mainly comes from countries such as Central Asia, Russia, and Myanmar. In 2023, the proportion of pipeline natural gas imports reached 42 %, with the Central Asia Natural Gas Pipeline and the China-Russia East Route Natural Gas Pipeline becoming core import channels.

From the perspective of demand structure, China's natural gas imports are mainly concentrated in urban gas, industrial fuel, and power generation sectors. In recent years, the demand growth in urban gas and power generation has been rapid, becoming the core factor driving the increase in natural gas imports. With the advancement of the domestic coal-to-gas project, urban gas demand continues to grow; meanwhile, natural gas power generation has become an important method for peak load regulation in the power system due to its cleanliness, leading to a continuous increase in natural gas demand in the power generation sector. The short-term decline in natural gas imports in 2024 was primarily attributed to the rapid growth of renewable energy generation such as wind and solar power, which replaced part of the natural gas power generation demand [18].

Coal: import volume continues to decline, with domestic production capacity expansion becoming the key factor.

China is a major global consumer of coal, and its coal import scale is significantly influenced by domestic production capacity, policy regulation, market demand, and other factors. In recent years, with the release of domestic coal production capacity and the advancement of clean transformation, the scale of coal imports has continued to decline. In the first three quarters of 2024, imports fell by 11.1 % year-on-year, making it the category with the largest decline in fossil energy imports.

In terms of import categories, China's coal imports are primarily thermal coal, with coking coal as a secondary component. In 2023, thermal coal imports accounted for over 75 % of total imports, mainly used for power generation and industrial heating, while coking coal imports accounted for approximately 25 %, primarily for steel smelting. From a demand structure perspective, domestic coal demand is mainly concentrated in power

generation, steel, and chemical industries. In recent years, with the clean transformation of the domestic power system, the proportion of thermal power installed capacity has continued to decline, leading to a slowdown in coal demand growth in the power sector. Meanwhile, capacity reduction and green transformation in the steel industry have also driven adjustments in coking coal demand.

From the perspective of policy regulation, China has introduced a series of policies to promote high-quality development in the coal industry, including releasing advanced production capacity, advancing clean coal utilization, and strengthening coal import controls. The rapid release of domestic coal production capacity has become the core factor driving the decline in coal imports. In 2023, domestic coal production reached 4.66 billion tons, setting a record high, effectively ensuring domestic coal supply and reducing dependence on imported coal. Meanwhile, China has strengthened quality control over coal imports and raised environmental standards for imported coal, which has also contributed to the reduction in the scale of coal imports (table 2.1).

Table 2.1 – China's import volume of major energy products (2021–2023) [10]

Product Type	2021 years (100million tons/100 million cubic meters)	2022 years (100 million tons/100 million cubic meters)	2023 years (100 million tons/100 million cubic meters)	Three-year average annual growth rate (%)
Crude oil	5.12	5.08	5.21	0.7
Natural gas	1.21	1.3	1.45	9.8
Coal	3.24	2.93	3.01	-3.6

2 Trade in new energy products: rapid export growth becomes a new trade engine.

With the rapid development of China's new energy industry, the export scale of new energy products such as photovoltaic modules, wind power equipment, energy storage devices, and new energy vehicles has grown rapidly, becoming a new engine for China's international energy trade. The trade structure has shifted from single photovoltaic modules to multi-category collaborative exports, and the export market has evolved from

Europe-dominated to globally diversified. China has become the world's largest exporter of new energy products and holds a core position in global renewable energy trade.

Photovoltaic modules: global leader in export scale with diversified market development.

China is a core producer and exporter of the global photovoltaic industry, ranking first in both the production and export scale of photovoltaic modules. In 2023, the export volume of photovoltaic modules reached 287GW, a year-on-year increase of 38.9 %, with export value reaching 58.4 billion dollars, accounting for over 70 % of the global total. In 2024, photovoltaic module exports continued to grow at a high rate, with the export volume in the first three quarters increasing by 25.6 % year-on-year, and the export market showing a trend of diversification.

From the perspective of export markets, China's photovoltaic module exports have expanded from traditional Europe to emerging markets such as the Asia-Pacific region, Latin America, and Africa. In 2023, the European market accounted for approximately 35 %, remaining the largest export market, but its share decreased by 20 percentage points compared to 2020. The Asia-Pacific market accounted for 28 %, the Latin American market for 15 %, and the African market for 10 %, with emerging markets becoming the core driving force behind the growth of photovoltaic module exports. Among them, countries such as India, Brazil, Australia, and Vietnam have become important importers of photovoltaic modules, with import volumes continuing to rise driven by local energy transitions and growing demand for photovoltaic installations.

From the perspective of product structure, China's photovoltaic module exports have been developing towards higher efficiency and premiumization, with large-size, high-conversion-efficiency photovoltaic modules becoming the mainstream export products. In 2023, high-efficiency photovoltaic modules accounted for over 85 % of exports. Meanwhile, the export scale of photovoltaic supporting products such as photovoltaic inverters and photovoltaic brackets has grown rapidly, becoming an important component of photovoltaic trade. China's photovoltaic industry has formed a complete industrial chain from poly-silicon, silicon wafers, cells, modules to supporting products, with the

advantages of this industrial chain serving as the core support for driving photovoltaic module exports [25; 30].

Wind power equipment: rapid expansion in export scale, with offshore wind power equipment becoming a new growth driver.

After years of development, China's wind power industry has formed a complete industrial chain, with rapid growth in the production and export scale of wind power equipment. In 2023, the export value of wind power equipment reached 10.8 billion dollars, a year-on-year increase of 45.3 %, accounting for over 40 % of the global total export volume of wind power equipment, making China the world's second-largest exporter of wind power equipment.

In terms of export products, China's wind power equipment exports include complete wind turbines, blades, gearboxes, generators, etc., among which complete wind turbines are the core export products, accounting for over 60 % of exports in 2023. Meanwhile, offshore wind power equipment has become a new growth point in exports. With the rapid development of the global offshore wind power industry, China's offshore wind power equipment has achieved continuous technological breakthroughs, with increasing unit capacity and rapid export growth. In 2023, the export value of offshore wind power equipment increased by 89.2 % year-on-year, mainly exported to regions such as Europe and Southeast Asia.

From the perspective of export markets, the export markets for China's wind power equipment are mainly concentrated in Europe, the Asia-Pacific region, and Latin America. In 2023, the European market accounted for 45 %, the Asia-Pacific market for 30 %, and the Latin American market for 15 %. Europe is the core region for global offshore wind power development, with continuously growing demand for wind power equipment. Countries in the Asia-Pacific region such as India, Vietnam, and Indonesia are accelerating the development of their wind power industries, becoming important import markets for wind power equipment. Countries in Latin America such as Brazil and Argentina are leveraging abundant wind energy resources to promote wind power installation projects, leading to a continuous increase in the import demand for wind power equipment [32].

Energy storage devices and new energy vehicles: emerging export categories with significant growth potential. In addition to photovoltaic and wind power equipment, energy storage devices and new energy vehicles have become emerging categories in China's international energy trade, with rapidly growing export volumes and enormous development potential, serving as an important supplement to China's new energy product exports [46].

In terms of energy storage equipment, China is a core producer in the global energy storage industry, ranking first in the world in the production and export scale of lithium battery energy storage equipment. In 2023, the export value of energy storage equipment reached 32 billion dollars, a year-on-year increase of 78.9 %. Major export products include lithium batteries, energy storage systems, and energy storage inverters. The export markets are mainly concentrated in Europe, Asia-Pacific, and North America. Driven by global energy transition and the growing demand for peak load regulation in power systems, the import demand for energy storage equipment continues to rise.

In the field of new energy vehicles, China is the world's largest producer and consumer of new energy vehicles. In recent years, its export volume has grown rapidly, reaching 1.08 million units in 2023, a year-on-year increase of 79.4 %, with export value reaching 20.9 billion dollars. Major export products include pure electric vehicles and plug-in hybrid vehicles. The export market has expanded from traditional regions such as Southeast Asia and Latin America to high-end markets like Europe and North America. In 2023, the European market accounted for 30 % of exports, becoming a key export market for China's new energy vehicles. The cost-performance ratio and technological advantages of China's new energy vehicles have become the core factors driving exports [47].

3 Energy service trade: gradual initiation and emerging as a new complement to trade.

With the transformation and upgrading of China's energy industry and the expansion of opening-up, energy service trade such as energy technical services, energy engineering services, and energy management services has gradually taken off, becoming a new supplement to China's international energy trade. The trade scale continues to expand, and

the service areas keep broadening, making it an important force driving the high-quality development of China's international energy trade.

In terms of energy technology services, China has continuously improved its technical service capabilities in new energy fields such as photovoltaics, wind power, and energy storage, providing technical services for the design, R&D, and commissioning of overseas new energy power stations. At the same time, it has also exported technical services in traditional energy sectors like clean coal utilization and natural gas liquefaction, primarily serving countries along the Belt and Road. In 2023, China's energy technology service exports reached 8.5 billion dollars, a year-on-year increase of 32.6 %, with the service market mainly concentrated in regions such as Asia-Pacific, Africa, and Latin America.

In the field of energy engineering services, China enterprises have leveraged their advantages in energy infrastructure construction to undertake numerous overseas energy projects, including crude oil and natural gas pipeline construction, new energy power station construction, and coal mining and processing engineering. In 2023, China's energy engineering service exports reached 21 billion dollars, representing a year-on-year increase of 25.8 %. Countries along the Belt and Road have become core markets for energy engineering services, with projects such as the China-Russia East-Route Natural Gas Pipeline, energy supporting projects for the China-Laos Railway, and photovoltaic power stations in Pakistan serving as typical examples.

In terms of energy management services, China enterprises provide overseas companies with energy efficiency improvement, carbon accounting, carbon trading, and other energy management services. With the continuous strengthening of global consensus on carbon emission reduction, the demand for energy management services continues to grow. In 2023, China's energy management service exports reached 3.5 billion dollars, a year-on-year increase of 65.4 %, making it the fastest-growing sector in energy service trade.

The origin of China's international energy trade and the layout of trade routes are the core to ensuring energy supply security. In recent years, China has accelerated the

diversification strategy of energy imports, with fossil fuel import sources shifting from highly concentrated to diversified, and trade routes transitioning from single maritime transport to equal emphasis on maritime and pipeline transport. The export market for new energy products has evolved from Europe-dominated to a globally diversified layout, with trade routes primarily relying on maritime and air transport, and the cross-border logistics system gradually improving [53].

1 Imported fossil fuels: diversified sources with combined maritime and land trade routes.

Crude oil: diversified import sources with maritime transport as the core channel.

China's crude oil import sources have long been highly concentrated in the Middle East region. In recent years, the country has accelerated the diversification strategy of import sources, with the proportion of the Middle East region continuously declining and the shares of Russia, Africa, and the Americas steadily increasing, gradually forming a diversified import pattern. In 2023, the Middle East accounted for 48 % of China's crude oil imports, a decrease of 15 percentage points compared to 2010; Russia accounted for 19 %, becoming China's second-largest crude oil import source; Africa accounted for 15 %; the Americas accounted for 12 %; and the Asia-Pacific region accounted for 6 %. In 2024, China's oil imports declined, but the trend toward diversification of sources was further strengthened, with Russia's crude oil import share rising to 21 %, making it China's largest crude oil import source.

China's crude oil import trade channels are primarily maritime, with pipeline transportation as a supplement, accounting for over 90 % of the total, making it the core channel for crude oil imports. Maritime routes mainly include the Middle East-Indian Ocean-Malacca Strait-South China Sea route, Africa-Indian Ocean-Malacca Strait-South China Sea route, America-Pacific-China coastal route, and Russia-Japan Sea-China northeastern coastal route. Among these, the Malacca Strait serves as the critical choke-point for China's maritime crude oil transportation, with approximately 80 % of maritime crude oil passing through it, exposing the channel's security to geopolitical risks. Pipeline transportation primarily includes the China-Kazakhstan crude oil pipeline, China-Russia

East Route crude oil pipeline, and China-Myanmar crude oil pipeline. In 2023, pipeline crude oil imports accounted for 8 % of total imports, an increase of 6 percentage points compared to 2010, with the proportion of pipeline transportation gradually rising and becoming an important supplement to crude oil imports [53].

To ensure the safety of crude oil maritime routes, China is accelerating the diversification of maritime channels, including the construction of overseas ports such as Gwadar Port and Djibouti Port, the opening of new routes like the Arctic shipping route and the China-Pakistan Economic Corridor, while strengthening naval escort and international maritime cooperation to enhance the security and resilience of maritime routes.

Natural gas: regionalization of import sources, with equal emphasis on pipelines and LNG shipping.

The proportion of pipeline natural gas sources from Central Asia and Russia remains stable, while the share of LNG import sources from Oceania and the Middle East continues to rise. In 2023, among China's natural gas import sources, Central Asia accounted for 35 %, Russia for 15 %, Australia for 20%, Qatar for 12 %, Malaysia for 8 %, and other regions for 10 %.

China's natural gas import trade channels exhibit a dual emphasis on pipelines and LNG shipping. In 2023, pipeline natural gas imports accounted for 42 %, while LNG shipping imports accounted for 58 %. Pipeline natural gas channels mainly include the Central Asia Gas Pipeline (Lines A, B, and C), the China-Russia East Route Gas Pipeline, and the China-Myanmar Gas Pipeline. Among them, the Central Asia Gas Pipeline is China's largest pipeline natural gas import channel, accounting for 65 % of total pipeline natural gas imports in 2023. The China-Russia East Route Gas Pipeline saw rapid growth in imports, reaching 25 % in 2023 and becoming the second-largest pipeline natural gas import channel. LNG shipping channels primarily include the Australia-Pacific-China coastal route, the Qatar-Indian Ocean-Malacca Strait-South China Sea route, and the Russia-Japan Sea-China northeastern coastal route. Domestically, 23 LNG receiving

terminals have been built, with a unloading capacity of 108 million tons per year, providing infrastructure support for LNG shipping imports (figure 2.2).

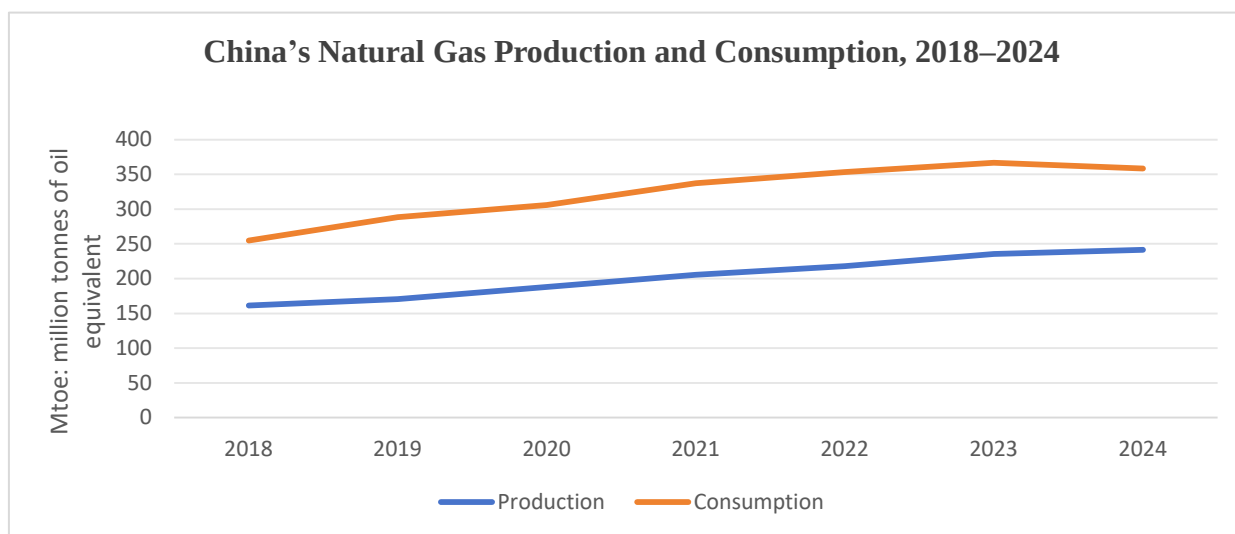


Figure 2.2 – China's natural gas production and consumption, 2018–2024 [10]

Coal: concentration of import sources, with maritime transport as the primary channel. China's coal import sources are relatively concentrated, mainly in countries such as Indonesia, Australia, Russia, and Mongolia. In recent years, influenced by policy adjustments and geopolitical factors, the structure of import sources has undergone adjustments, with Indonesia's share continuously increasing, Australia's share declining, and Russia and Mongolia's shares steadily rising. In 2023, among China's coal import sources, Indonesia accounted for 55 %, becoming the largest coal import source for China; Russia accounted for 15 %; Mongolia accounted for 10 %; Australia accounted for 8 %; and other regions accounted for 12%. In the first three quarters of 2024, coal imports declined, but the source structure was further optimized, with the import share of neighboring countries such as Russia and Mongolia rising to 28 %.

China's coal import trade channels are primarily maritime, with land transport as a supplement, accounting for over 85 % of the total. Land transport mainly includes railway and road transport along the China-Mongolia border and China-Russia border. Maritime routes primarily consist of the Indonesia-South China Sea-China southeastern coastal route,

Australia-Pacific-China southeastern coastal route, and Russia-Japan Sea-China northeastern coastal route, mainly transporting coal to power and steel enterprises along China's southeastern coast. Land transport is mainly concentrated at the Ganqimao Port and Ceke Port along the China-Mongolia border, as well as the Manzhouli Port and Suifenhe Port along the China-Russia border, primarily delivering coal to coal-consuming enterprises in Inner Mongolia and northeastern China (figure 2.3).

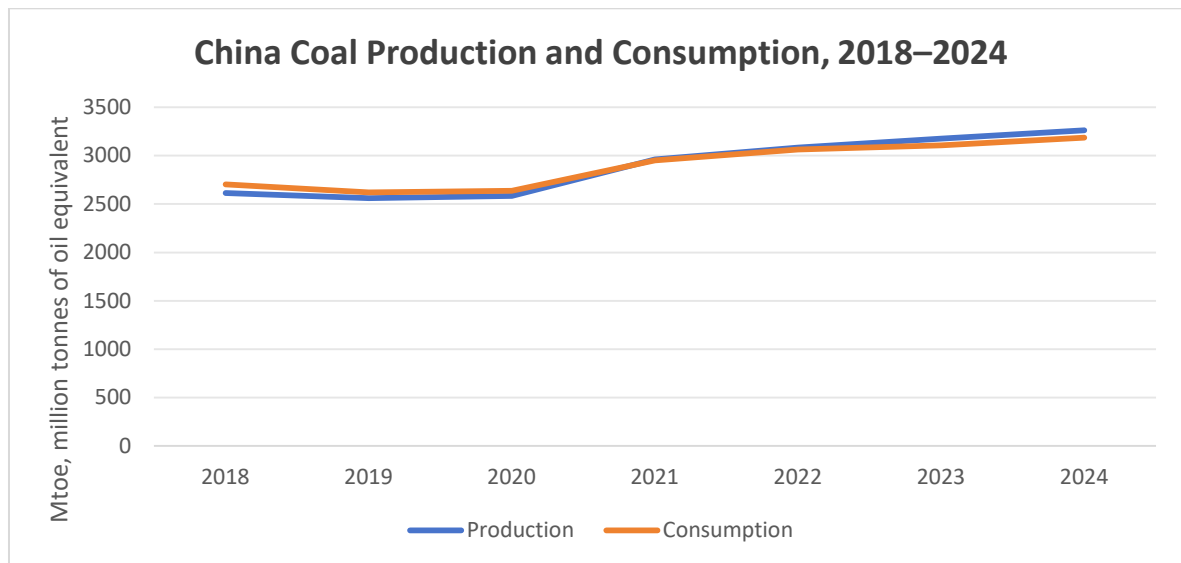


Figure 2.3 – China’s coal production and consumption, 2018–2024 [10]

2 Export of new energy products: market globalization and facilitation of trade channels.

China's new energy product export market exhibits global characteristics, expanding from traditional European markets to global markets such as Asia-Pacific, Latin America, Africa, and North America. The trade channels are primarily maritime with air transport as a supplement, and the cross-border logistics system is gradually improving. New trade models such as overseas warehouses and cross-border e-commerce have become important forces driving the export of new energy products.

In terms of export market layout, China's new energy product exports have formed a global pattern with Europe as the core and emerging markets as growth points. The European market, due to its rapid energy transition pace and high demand, remains the

core export market for China's photovoltaic, wind power, and energy storage equipment, accounting for over 35 % in 2023. The Asia-Pacific market, leveraging its large population, rapidly growing energy demand, and advancing energy transition, has become the largest growth market for new energy product exports, accounting for 28 % in 2023. Latin America and Africa markets, with their weak energy infrastructure and significant potential for new energy development, have emerged as emerging growth markets, collectively accounting for 25 % in 2023. Although affected by trade barriers, the North American market continues to see growing import demand for new energy products, accounting for 12 % in 2023 [42].

In terms of trade channel layout, China's new energy product exports primarily rely on maritime transport, with air transport as a supplement, accounting for over 90 % of the total. Maritime transport is mainly used for transporting large-volume and heavy-weight products such as photovoltaic modules, wind power equipment, and energy storage devices, while air transport is primarily used for high-value-added, small-volume products like new energy vehicle components and energy storage chips. Maritime channels mainly include the China coastal ports-Malacca Strait-Indian Ocean-Europe and Africa route, China coastal ports-Pacific-America route, and China coastal ports-South China Sea-Southeast Asia route. Ports such as China's Shanghai Port, Ningbo Port, and Shenzhen Port have become core hubs for new energy product exports. Meanwhile, China is accelerating the construction of overseas logistics infrastructure, establishing overseas warehouses and logistics centers in regions such as Europe, Southeast Asia, and Latin America to improve the cross-border logistics system and enhance the logistics efficiency of new energy product exports [58].

In terms of new trade models, cross-border e-commerce has become a significant force in promoting the export of new energy products. In 2023, China's cross-border e-commerce exports of new energy products reached 12.5 billion dollars, a year-on-year increase of 95.8 %, mainly selling products such as small photovoltaic systems, energy storage power banks, and new energy vehicle accessories. Meanwhile, Chinese companies are accelerating their overseas localization efforts by establishing production bases and

assembly factories abroad to reduce the impact of trade barriers and enhance the local market competitiveness of new energy products. In 2023, Chinese photovoltaic companies built production bases with a capacity of 35GW overseas, while wind power companies established 12 assembly factories abroad.

2.2 Driving factors and potential of China's international energy trade development

China's economy has shifted from a stage of high-speed growth to a stage of high-quality development, with fundamental changes in the quality, efficiency, and driving forces of economic development. This has driven energy demand to transition from rapid growth in total volume to structural optimization and upgrading, while continuously elevating the category structure, demand structure, and quality requirements of international energy trade.

On the one hand, high-quality economic development has led to a moderate increase in total energy consumption, providing basic demand support for fossil fuel imports. Although China's energy intensity in economic development continues to decline, the sustained growth in economic output still drives a moderate increase in total energy consumption. In 2023, China's total primary energy consumption reached 5.41 billion tons of standard coal, up 3.7 % year-on-year, with the consumption of clean fossil fuels such as crude oil and natural gas growing faster than coal, becoming the core factor driving fossil fuel imports. Meanwhile, high-quality economic development has promoted energy consumption upgrades in key sectors such as industry, transportation, and construction. The development of high-end manufacturing and chemical industries in the industrial sector has driven the growth in demand for crude oil and natural gas, while the development of aviation and maritime industries in the transportation sector has maintained the demand for refined oil imports. The demand for clean heating in the construction sector has also contributed to the growth in natural gas imports.

On the other hand, high-quality economic development has increased the demand for clean and efficient energy, driving the transition of energy import structures toward low-carbon. As China's economy shifts toward green, low-carbon, and high-end manufacturing, energy consumption patterns with high energy consumption and high pollution are gradually being phased out, leading to a sustained increase in demand for clean energy and high-end energy products. For example, the high-end chemical industry's growing demand for high-quality crude oil and special natural gas has shifted crude oil and natural gas imports toward higher-quality categories. Data centers and the new energy industry have also raised their requirements for clean electricity, indirectly boosting the trade of natural gas and renewable energy-related products. Additionally, the demand for clean energy in residential consumption upgrades, such as urban gas and household heating, has further contributed to the steady growth in natural gas imports [60].

The proposal and advancement of the carbon peak and carbon neutrality goals serve as the core guidance for China's energy structure transition, and have also become a key endogenous factor driving the greening and low-carbon transformation of international energy trade structures. This has forced the optimization of traditional fossil energy trade and accelerated the rapid development of new energy product trade.

In traditional fossil fuel trade, the dual carbon goals have driven a shift in fossil energy imports from quantitative expansion to quality optimization and structural adjustment. As a high-carbon emission source, coal imports continue to decline due to dual pressures from domestic production capacity expansion and low-carbon policy regulations. Import priorities now lean toward high-quality thermal coal and low-sulfur coking coal to reduce carbon intensity in coal consumption. Crude oil import demand is transitioning from refined oil consumption to chemical feedstock demand, where carbon emissions from processing stages are easier to control while enhancing crude oil utilization value – aligning with low-carbon development goals. Natural gas, as a clean fossil energy source and transitional fuel for energy transition, has seen short-term import adjustments but maintains steady long-term growth. Import categories increasingly favor liquefied natural gas (LNG) to achieve diversified and flexible supply channels [57].

In terms of new energy product trade, the dual carbon goals have driven the rapid development of China's domestic new energy industry, forming a complete industrial chain and industrial advantages, providing solid industrial support for the export of new energy products. To achieve the dual carbon goals, China has introduced a series of supportive policies for the new energy industry, including subsidies for photovoltaic and wind power installations, support for new energy technology research and development, and planning for the new energy vehicle industry, promoting the large-scale and high-end development of photovoltaic, wind power, energy storage, and new energy vehicles. In 2023, China's photovoltaic module production accounted for over 80 % of the global total, wind power equipment production accounted for over 70 %, and new energy vehicle production accounted for over 60 %. The complete industrial chain has brought cost advantages and technological advantages, becoming the core driving force for the rapid growth of new energy product exports. Meanwhile, competition and upgrading in the domestic new energy market have also prompted enterprises to accelerate technological innovation and product upgrades, enhancing the international competitiveness of new energy products [34].

China's energy resource endowment exhibits the characteristics of abundant coal, scarce oil, and limited gas, with prominent structural contradictions between energy supply and demand. The domestic supply of clean energy such as crude oil and natural gas is difficult to meet the needs of economic and social development as well as energy transition, becoming the core factor driving the long-term growth of crude oil and natural gas imports.

In terms of crude oil, China's crude oil reserves are limited, and extraction is difficult. Domestic crude oil production has remained stable for a long time, making it hard to meet the rapidly growing consumer demand. In 2023, China's crude oil production reached 205 million tons, up 2.9 % year-on-year, but still far below the import volume of 560 million tons, with an external dependence on crude oil exceeding 70 %. Domestic crude oil resources are mainly concentrated in regions such as the Bohai Bay, Songliao Basin, and Tarim Basin. New reserves are primarily low-grade and high-cost crude oil,

with extraction costs higher than international crude oil prices, which has constrained a significant increase in domestic crude oil production. Meanwhile, the scaled and integrated development of the domestic refining industry has led to a continuous increase in crude oil demand, further exacerbating the structural shortage of crude oil supply and fostering sustained import demand [29].

In terms of natural gas, China's natural gas resources are unevenly distributed, mainly concentrated in central and western regions as well as offshore areas, with high extraction and transportation costs, making it difficult for domestic production growth to keep pace with demand growth. In 2023, China's natural gas production reached 235.3 billion cubic meters, a year-on-year increase of 7.4 %, but imports amounted to approximately 110 million tons (equivalent to around 150 billion cubic meters), with an external dependence rate approaching 45 %. Although domestic natural gas exploration and development have made continuous breakthroughs, low-permeability and high-sulfur gas fields account for a significant proportion, requiring advanced extraction technologies. Moreover, the distance between natural gas production areas in central and western regions and consumption areas in the east, coupled with high construction costs for long-distance pipelines, has constrained domestic natural gas supply capacity. Meanwhile, the advancement of the coal-to-gas project and the development of natural gas power generation have driven sustained growth in natural gas demand, further exacerbating the structural shortage in natural gas supply [37].

In terms of new energy products, China has established advantages in the manufacturing of new energy equipment such as photovoltaic and wind power, but faces supply shortages in key mineral resources for new energy, which has spurred import demand for related resources. Lithium, cobalt, nickel, and rare earths are core raw materials for industries such as photovoltaic, wind power, energy storage, and new energy vehicles. China's reserves and production of these resources struggle to meet the rapidly growing domestic demand for new energy industries. In 2023, China's dependence on imported lithium resources exceeded 70 %, cobalt resources exceeded 90 %, and nickel resources exceeded 80 %. The import of key mineral resources has become a crucial

support for ensuring the development of China's new energy industry, also driving the evolution of China's new energy trade from equipment exports to a dual model of resource imports + equipment exports (figure 2.4).

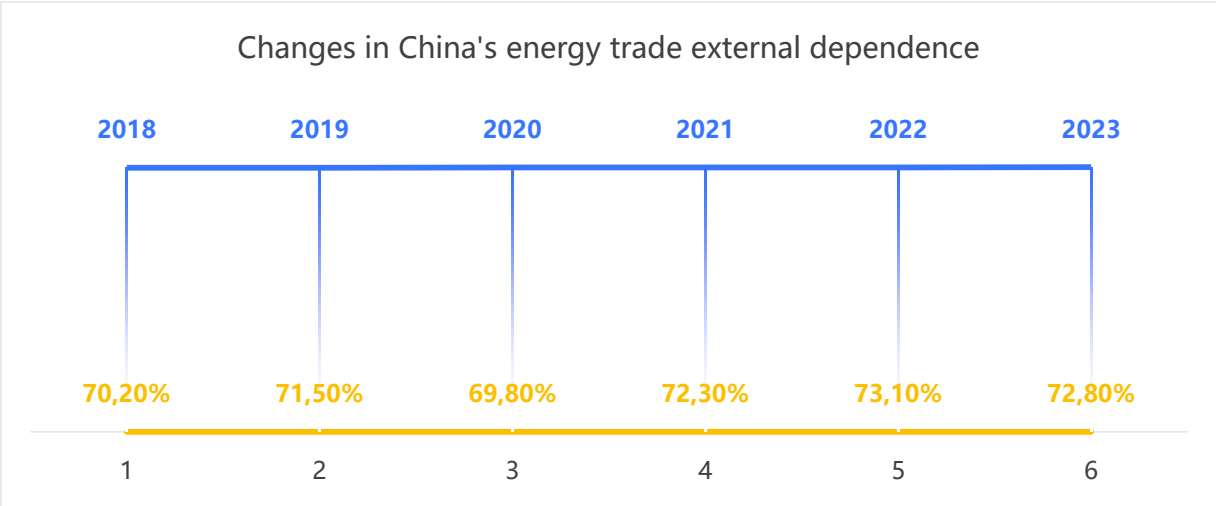


Figure 2.4 – Global energy trade year on year growth rate, 2010–2023 [10; 18]

China's industrial structure is transitioning from industry dominance to coordinated development of primary, secondary, and tertiary industries. Within the industrial sector, it is upgrading from heavy and chemical industries dominance to high-end manufacturing and strategic emerging industries dominance. The optimization and upgrading of the industrial structure drive the diversification of energy consumption categories, thereby promoting the diversified development of international energy trade categories.

On one hand, the development of high-end manufacturing and strategic emerging industries has driven import demand for premium energy products and specialized energy solutions. High-end manufacturing sectors such as advanced equipment manufacturing, electronics, and bio-pharmaceuticals have increased their reliance on clean and efficient energy sources like electricity and natural gas, while simultaneously boosting demand for energy derivatives including specialty fuels and high-end chemical raw materials. This trend is shifting crude oil and natural gas imports toward higher-quality and specialized categories. Meanwhile, the growth of strategic emerging industries encompassing new energy technologies, advanced materials, and environmental protection initiatives has

fueled demand for critical minerals for renewable energy, high-performance energy storage systems, and hydrogen-based energy products, further propelling import trade in these sectors [47].

On the other hand, the rapid development of the service sector has reduced overall energy consumption intensity while driving the growth in demand for civilian energy and clean energy. The energy consumption intensity of the service sector is much lower than that of industry, and its increasing proportion helps reduce China's overall energy consumption intensity and alleviate the total pressure on fossil energy imports. Meanwhile, the development of sectors such as transportation, logistics, and commerce within the service industry has boosted the demand for energy products like refined oil and natural gas. The growth of residential services has further increased the demand for clean energy sources such as residential gas and electricity, further promoting the transition of energy trade structures toward cleaner alternatives. Additionally, the advancement of agricultural modernization has driven the clean and mechanized use of energy in agricultural production, fostering the trade development of energy products like natural gas and biomass energy [58].

The profound restructuring of the global energy landscape, geopolitical landscape, and economic trade landscape has brought numerous external opportunities for the development of China's international energy trade. The renewable energy trade opportunities driven by global energy transition, regional energy cooperation opportunities arising from the deepening of the Belt and Road Initiative, market expansion opportunities brought about by the diversification of the global trading system, and energy demand growth opportunities resulting from the development of emerging economies collectively constitute the external drivers for the development of China's international energy trade.

1 Global energy transition drives rapid development of renewable energy trade.

The global energy transition has shifted from concept advocacy to practical implementation, with renewable energy becoming the core direction of global energy development. This has brought vast market opportunities for China's new energy product

exports and emerged as a key external opportunity to promote the green development of China's international energy trade [35].

Firstly, the continuous growth in global renewable energy installed capacity demand has provided enormous market demand for China's photovoltaic and wind power equipment exports. According to the IEA's Global Renewable Energy Outlook (2024), global renewable energy installed capacity will increase by over 8,000 GW from 2023 to 2030, with photovoltaic and wind power installations accounting for more than 90 % of the new additions. Emerging economies have become the core markets for renewable energy capacity growth. Countries such as India, Vietnam, and Indonesia in Asia, South Africa and Nigeria in Africa, and Brazil and Argentina in Latin America, with weak energy infrastructure and rapidly growing energy demand, are accelerating renewable energy development, leading to a sustained rise in demand for photovoltaic and wind power equipment. Developed countries in Europe and North America, aiming to achieve carbon reduction targets, are continuously expanding renewable energy installed capacity, driving demand growth for high-efficiency and high-end photovoltaic and wind power equipment. As the world's largest producer of photovoltaic and wind power equipment, China has become a core supplier of renewable energy installed capacity products globally, leveraging its advantages in industrial chain, cost, and technology, with its export markets continuously expanding [35].

Secondly, the rapid rise of the global energy storage market has brought new growth opportunities for China's energy storage equipment exports. With the expansion of renewable energy installed capacity and the increasing demand for peak shaving and frequency regulation in power systems, energy storage has become a core component in ensuring stable power system operations, and the global energy storage market has entered a phase of rapid development. In 2023, the global installed capacity of energy storage reached 300GW, representing a year-on-year growth of over 40 %, and is expected to exceed 1500GW by 2030. China has established a complete industrial chain in the field of lithium battery energy storage equipment, with lithium battery production accounting for over 70 % of the global total. The country's energy storage system integration capabilities

rank among the world's top, and energy storage equipment exports have become a new growth point in China's new energy product trade, with export markets expanding from Europe and North America to Asia-Pacific, Latin America, and Africa [45].

Thirdly, the rapid development of the global new energy vehicle market has brought broad opportunities for China's new energy vehicle exports. With the advancement of electrification transformation in the global transportation sector, new energy vehicles have become the core direction of global automotive industry development. In 2023, global new energy vehicle sales reached 14 million units, representing a year-on-year growth of over 35 %, with emerging economies becoming the key markets driving sales growth. After years of development, China's new energy vehicle industry has established technological, brand, and cost advantages. It has not only achieved large-scale production in pure electric vehicles and plug-in hybrid electric vehicles but also made breakthroughs in core technologies such as intelligent connectivity and power batteries. New energy vehicle exports have expanded from traditional markets like Southeast Asia and Latin America to high-end markets such as Europe and North America, becoming an important component of China's new energy product exports.

2 Global trade system diversification expands energy trade market space.

The global trade system is transitioning from uni-polarity to multi-polarity, with emerging economies playing an increasingly prominent role in global trade. Regional trade agreements and multilateral cooperation mechanisms such as the Regional Comprehensive Economic Partnership (RCEP), BRICS cooperation mechanisms, and the Shanghai Cooperation Organization are continuously improving, bringing new opportunities for China's international energy trade market expansion and driving China's energy trade market to evolve from Europe and America dominance to global diversification.

First, the implementation of regional trade agreements has reduced tariffs and non-tariff barriers in energy product trade, promoting the liberalization of energy trade within the region. As the world's largest free trade agreement, RCEP covers 15 countries including China, ASEAN, Japan, South Korea, Australia, and New Zealand. The agreement imposes tariff reductions on new energy products such as photovoltaic modules,

wind power equipment, and energy storage devices, and clearly stipulates trade facilitation measures for fossil energy products like crude oil, natural gas, and coal, driving the expansion of energy trade between China and RCEP member countries. In 2023, crude oil imports from China and RCEP member countries accounted for over 35 %, natural gas imports for over 40%, and new energy product exports for over 30 %, making RCEP a key market for China's international energy trade. Additionally, free trade agreement negotiations and implementations between China and ASEAN, Central Asia, Africa, and other regions have further reduced trade barriers in energy products and expanded the energy trade market space [41].

Secondly, the rapid development of emerging economies has led to increased energy demand and the need for energy transition, making them a new growth market for China's energy trade. Emerging economies such as India, Brazil, South Africa, and Indonesia are experiencing rapid economic growth and sustained energy demand, while accelerating energy transition, resulting in synchronized growth in import demand for fossil fuels and new energy products. China's energy trade cooperation with emerging economies continues to deepen. In terms of fossil fuel trade, China has become an important export market for crude oil and natural gas to emerging economies. In terms of new energy product trade, China has become a core supplier of photovoltaic, wind power, and energy storage equipment to emerging economies. Emerging economies have become the core driving force behind the growth of China's international energy trade [41].

Thirdly, the improvement of multilateral cooperation mechanisms has provided platform support for international energy trade cooperation in China, promoting the diversification of energy trade rules. Multilateral cooperation mechanisms such as BRICS and the Shanghai Cooperation Organization have become important platforms for energy trade cooperation between China and emerging economies. By establishing energy cooperation working groups, signing energy trade cooperation agreements, and conducting energy production capacity cooperation, they have expanded the scale of energy trade between China and BRICS countries as well as SCO member states. Meanwhile, China has participated in the formulation of global energy trade rules through multilateral

cooperation mechanisms, promoting the establishment of energy trade rules that align with the interests of developing countries, reducing the impact of trade barriers in developed countries, and expanding the market space for energy trade [41].

3 Restructuring of the global energy governance system enhances China's participation.

The global energy governance system is undergoing profound restructuring. The influence of traditional energy governance institutions (such as the IEA and OPEC) has declined, while emerging multilateral energy governance platforms continue to emerge. Developing countries are gaining increasing influence in global energy governance, bringing new opportunities for China to participate in global energy governance and promote energy trade development [30]. As the world's largest energy consumer, importer, and exporter of new energy products, China's role in global energy governance has been steadily rising, making it a key participant in the restructuring of the global energy governance system (figure 2.5).

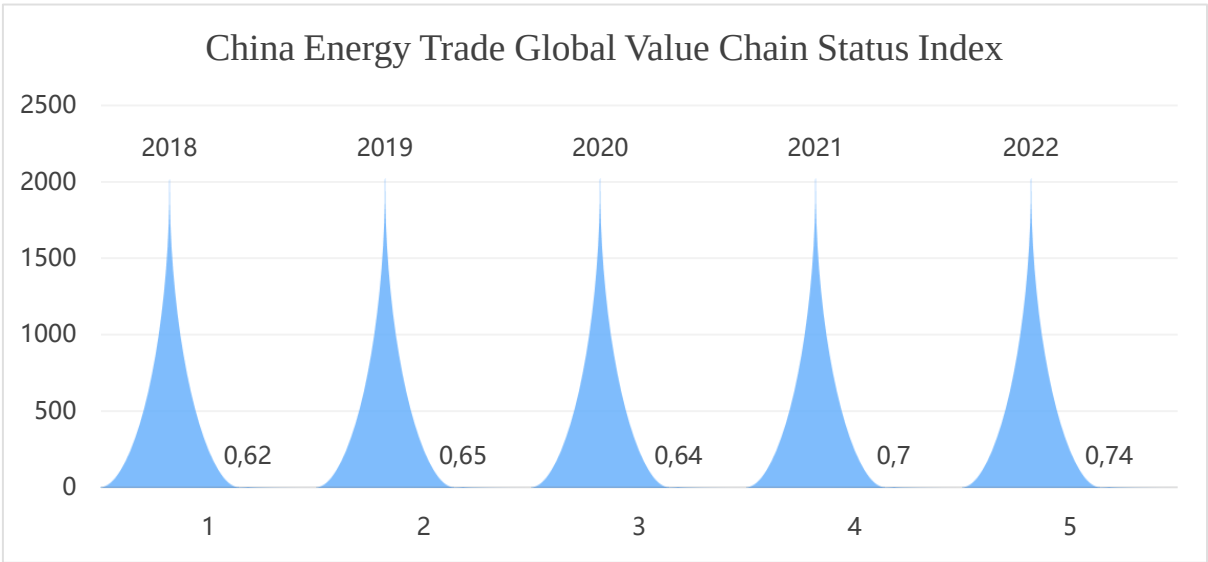


Figure 2.5 – China energy trade global value chain status index [10; 18]

China actively engages in energy governance cooperation through multilateral platforms such as the G20, BRICS, and the Shanghai Cooperation Organization, promoting the establishment of new financial institutions like the Asian Infrastructure

Investment Bank (AIIB) and the New Development Bank of BRICS to provide funding support for global energy infrastructure construction and the development of the new energy industry. China initiated the Global Energy Interconnection Development and Cooperation Organization to advance global energy connectivity and renewable energy development. China has also worked with countries such as Russia and Kazakhstan to promote the establishment of the SCO Energy Cooperation Mechanism, aiming to build a regional energy trade community [1].

The restructuring of the global energy governance system has promoted the development of energy trade rules in a more equitable, just, and inclusive direction, reduced the monopoly of developed countries on energy trade rules, and created a favorable international environment for China's energy product exports. At the same time, China has participated in global energy governance to drive the formulation of renewable energy trade rules, governance rules for key mineral resources of new energy, carbon trading rules, and others, integrating its industrial advantages and development needs into the formulation of global energy trade rules. This has enhanced China's voice and influence in global energy trade and provided institutional safeguards for the high-quality development of China's international energy trade.

Innovative breakthroughs and industrial applications in energy technology serve as the core support for advancing China's international energy trade. Progress in fossil energy extraction and transportation technologies has enhanced the efficiency and safety of fossil energy imports. Breakthroughs in new energy technologies have driven the development of the new energy industry and improved the competitiveness of new energy product exports. The advancement of energy digitalization and intelligent technologies has boosted the efficiency of energy trade and fostered model innovation. The development of low-carbon energy technologies has facilitated the low-carbon transition of traditional fossil energy trade, providing technical safeguards for the high-quality development of China's international energy trade [32].

The improvement of China's domestic energy trade policies, the advancement of institutional innovation, and the establishment of international energy cooperation

mechanisms have provided solid institutional safeguards for the development of China's international energy trade. Domestic policy guidance and support have promoted the optimization of energy trade structure and the enhancement of industrial competitiveness. The progress of institutional innovation has elevated the facilitation level and market vitality of energy trade. The construction of international cooperation mechanisms has reduced geopolitical risks and trade barriers in energy trade, driving its international development.

The Chinese government has introduced a series of energy trade-related policies, providing policy guidance and support for the development of China's international energy trade in areas such as energy import diversification, support for the new energy industry, facilitation of energy trade, and low-carbon trade development, thereby promoting the expansion of energy trade scale, structural optimization, and quality improvement.

China continues to promote institutional innovation in the energy sector, improve the energy market system, energy regulatory system, and energy reserve system, enhance the market-oriented level of energy trade and risk prevention capabilities, providing institutional support for the high-quality development of China's international energy trade.

In terms of innovation in the energy market system, China is accelerating market-oriented reforms in the energy sector, improving market-based pricing mechanisms for energy products such as crude oil, natural gas, and electricity, and promoting the alignment of the energy market with international markets. For example, efforts have been made to advance the development of crude oil futures markets. The crude oil futures traded on the Shanghai International Energy Exchange (INE) have become the world's third-largest crude oil futures trading market, achieving RMB-denominated pricing and settlement for crude oil, thereby enhancing China's influence in international crude oil pricing. Market-oriented reforms in natural gas have also been promoted, including improvements to the gate station pricing mechanism and alignment of natural gas prices with international markets, which has elevated the marketization level of natural gas trade. Additionally, market-oriented reforms in electricity have been implemented, including

enhancements to the electricity spot market and medium-to-long-term trading markets, as well as efforts to facilitate the consumption and trade of renewable energy power [49].

In terms of innovation in the energy reserve system, China is accelerating the improvement of fossil energy reserve systems for crude oil, natural gas, and coal, establishing an energy reserve system that combines government reserves with corporate reserves and complements strategic reserves with commercial reserves. This enhances emergency response capabilities for energy supply and reduces market risks and geopolitical risks in energy trade. For example, efforts are being made to accelerate the construction of national crude oil reserve bases to improve strategic crude oil reserve capacity; to advance the development of natural gas reserve systems by encouraging enterprises to build LNG storage tanks, underground gas storage facilities, and other natural gas reserve infrastructure; and to refine coal reserve systems by constructing coal reserve bases to ensure stable coal supply. As of 2023, China's strategic crude oil reserve capacity reached 570 million tons, natural gas reserve capacity exceeded 30 billion cubic meters, and coal reserve capacity surpassed 150 million tons. The improvement of the energy reserve system provides crucial safeguards for the stable development of energy trade [50].

China actively promotes the establishment and deepening of international energy cooperation mechanisms, establishes bilateral and multilateral energy cooperation mechanisms with countries around the world, participates in the formulation of global energy governance rules, promotes the liberalization and facilitation of energy trade, reduces geopolitical risks and trade barriers in energy trade, and provides institutional safeguards for the international development of China's international energy trade.

In terms of multilateral energy cooperation mechanisms, China actively participates in energy cooperation on multilateral platforms such as the G20, BRICS, Shanghai Cooperation Organization (SCO), and Asia-Pacific Economic Cooperation (APEC), promoting the establishment of regional energy trade communities and improving multilateral energy trade rules. For example, under the SCO framework, efforts are made to establish the SCO Energy Cooperation Committee, build a regional energy connectivity

network, and facilitate intra-regional trade in crude oil, natural gas, and new energy products; under the BRICS framework, efforts are made to advance the BRICS Energy Cooperation Mechanism, engage in energy production capacity cooperation and new energy technology cooperation, and promote energy trade development among BRICS countries; under the APEC framework, efforts are made to facilitate energy trade and promote low-carbon development, participating in the formulation of energy trade rules for the Asia-Pacific region. The establishment of multilateral energy cooperation mechanisms has enhanced energy trade cooperation between China and emerging economies, strengthening China's voice in global energy governance (table 2.2).

Table 2.2 – Comparison of energy trade competitiveness indicators between China and major countries [10; 18]

Country	RCA Index (Comparative Advantage)	TC Index (Competitive Advantage)	International market share, %
China	1.8	0.32	14.2
America	1.5	0.28	12.7
Germany	1.3	0.21	10.5
Japan	0.9	-0.15	7.8
Russia	2.2	0.45	16.8

Driven by synergistic factors at domestic, international, technological, and institutional levels, China's international energy trade still holds tremendous development potential. Fossil energy imports will evolve toward premiumization, refinement, and diversification, while exports of new energy products will upgrade to high-end, multi-category, and globalization. Energy service trade will become a new growth driver, regional energy cooperation will deepen further, and the integration of energy trade with carbon trading will emerge as a new development direction, propelling China's international energy trade toward security, resilience, greenness, and high-quality development [49].

In the future, China's fossil energy imports will move away from the quantity expansion model and develop towards high-quality, refined, and diversified approaches. The import structure will continue to optimize, with further diversification of import sources and trade channels, while import efficiency and safety will keep improving, indicating significant potential for further optimization.

In terms of import categories, crude oil imports will prioritize high-quality and specialized crude oils to align with the domestic refining industry's transition toward integrated chemical production.

In terms of trade routes, crude oil imports will further optimize the dual-channel framework of marine transport + pipelines. The utilization efficiency of new maritime routes such as the Arctic shipping route and China-Pakistan Economic Corridor will improve, while cross-border crude oil pipeline capacity will expand. Natural gas imports will enhance four major import corridors in Northwest, Northeast, Southwest, and maritime regions, with LNG receiving terminals boosting unloading capabilities and cross-border natural gas pipeline construction accelerating. Coal imports will refine the maritime-land transportation pattern, with enhanced capacity for cross-border coal transport routes between China-Mongolia and China-Russia.

2.3 Core challenges facing the development of China's international energy trade

Against the backdrop of global energy landscape restructuring, frequent geopolitical conflicts, and accelerated low-carbon transition, China's international energy trade development has encountered numerous opportunities but also faces a series of core challenges. Supply chain security risks triggered by geopolitical conflicts continue to intensify, structural and institutional contradictions in the low-carbon transition process are becoming increasingly prominent, and the lack of discourse power in global energy governance urgently needs to be addressed. Technical barriers and market competition pressures in new energy trade are continuously increasing, while the resilience and

efficiency of domestic energy trade systems still need improvement. These challenges severely constrain the high-quality development of China's international energy trade.

1 Escalation of geopolitical conflicts increases supply chain security risks.

The profound adjustment of the global geopolitical landscape, intensified great power competition, and frequent regional conflicts have further strengthened the geopolitical attributes of energy trade. China's international energy trade supply chain security faces severe challenges, with issues such as concentrated energy import sources and single trade routes remaining unresolved. Geopolitical conflicts are prone to trigger disruptions in energy supply chains and energy price fluctuations, severely impacting the stability and security of China's energy trade.

Although China is accelerating the diversification strategy of energy imports and continuously expanding the sources of fossil energy imports, there remains a certain risk of concentration. The imports of some energy categories are highly dependent on a few countries or regions, and geopolitical conflicts may easily restrict import sources, affecting the stability of energy supply.

In terms of crude oil, although China's crude oil imports have gradually reduced their dependence on the Middle East, the region remains the largest source of imports, accounting for 48 % in 2023. The geopolitical situation in the Middle East remains complex, with ongoing developments such as the Iranian nuclear issue, the Yemen conflict, and the rivalry between Saudi Arabia and Iran. Geopolitical conflicts can easily hinder Middle Eastern crude oil exports, affecting the stability of China's crude oil imports. Meanwhile, Russia has become China's second-largest source of crude oil imports, with its share rising to 21 % in 2024.

In terms of natural gas, China's natural gas imports are highly dependent on countries and regions such as Central Asia, Russia, and Australia. In 2023, the import share from Central Asia and Russia reached 50 %, while that from Australia accounted for 20 %. Political instability in some Central Asian countries may affect the transportation safety of cross-border natural gas pipelines. As a developed country, Australia's energy

trade policies are prone to geopolitical influences, which may impose restrictions on China's LNG imports.

In terms of coal, China's coal imports are highly dependent on Indonesia, accounting for 55 % in 2023. Indonesia's coal export policies are easily influenced by domestic economic and political factors, and it has repeatedly issued coal export bans, leading to short-term fluctuations in China's coal imports. Meanwhile, although Australia's share of coal imports has declined, it remains an important source of imports. Fluctuations in China-Australia relations can easily affect the stability of coal imports [28].

2 Energy trade channels exhibit homogenization and geopolitical bottlenecks.

Although China's energy trade routes are gradually developing in a diversified direction with equal emphasis on marine transport + pipelines, there still exist issues of singularity and geopolitical bottlenecks. Marine transport routes are highly dependent on strategic choke-points such as the Strait of Malacca, while pipeline routes are significantly influenced by geopolitical factors. Geopolitical conflicts can easily lead to disruptions in trade routes, affecting the security of energy trade.

In terms of maritime routes, China's maritime imports of fossil fuels such as crude oil, natural gas, and coal are highly dependent on the Strait of Malacca, with approximately 80 % of maritime crude oil and 60 % of maritime LNG passing through it. The Strait of Malacca is jointly managed by Singapore, Malaysia, and Indonesia, and its geopolitical position is sensitive, making it significantly influenced by military actions from Western powers like the United States. In the event of geopolitical conflicts, the security of passage through the Strait of Malacca would be severely threatened, leading to disruptions in China's maritime imports of fossil fuels. Additionally, China's maritime energy transport lacks sufficient long-distance shipping capacity, with a low ownership rate of ocean tankers and LNG carriers, relying largely on international shipping companies. Geopolitical conflicts could easily result in sanctions against these companies, preventing them from providing transportation services to China and thereby affecting energy maritime imports [38].

In terms of pipeline corridors, China's cross-border energy pipelines are mainly concentrated in the northwest, northeast, and southwest directions, which are significantly influenced by the geopolitical situation and international relations of countries along the routes. For example, the Central Asia Natural Gas Pipeline passes through countries such as Kazakhstan, Uzbekistan, and Turkmenistan, where political situations and policy changes in these countries can easily affect the transportation safety and volume of the pipeline. The China-Myanmar crude oil/natural gas pipeline passes through Myanmar, where domestic political situations and ethnic conflicts can impact the normal operation of the pipeline.

3 Structural and institutional contradictions in the low-carbon transition process.

China is accelerating the dual carbon goals, with the energy structure transition entering a critical phase. The low-carbon transition process faces a series of structural and institutional contradictions, making it increasingly difficult to balance traditional fossil energy imports with the development of new energy trade. The constraints of low-carbon trade barriers are becoming more prominent, and the connection between domestic and international carbon markets remains inadequate. The low-carbon transition of energy trade lacks robust institutional safeguards, which severely hinders the green development of China's international energy trade [17].

As the world's largest developing country, China still requires a certain scale of fossil energy support for its socio-economic development. The import demand for fossil fuels such as crude oil and natural gas will persist for a long time. Meanwhile, the low-carbon transition demands reducing fossil energy consumption and expanding new energy trade. There exists a significant structural contradiction between traditional fossil energy imports and the development of new energy trade, making it increasingly difficult to balance their development.

On the one hand, domestic energy demand for economic and social development will continue to grow moderately, and fossil fuel imports remain a crucial support for ensuring domestic energy supply. China is still in the mid-to-late stages of industrialization and urbanization, with energy demand in sectors such as industry,

transportation, and construction continuing to rise. Although energy consumption intensity keeps declining, total energy consumption will still maintain moderate growth. Coal, as the dominant domestic energy source, will see its consumption share gradually decrease but remain at a certain level for the long term. Crude oil and natural gas, as clean fossil fuels, serve as transitional options for energy transition, and import demand will persist for the foreseeable future. By 2030, China's dependence on imported crude oil is expected to remain around 70 %, while its dependence on imported natural gas will exceed 50 %. The long-term existence of fossil fuel imports creates a contradiction with low-carbon transition goals that aim to reduce fossil fuel consumption and carbon emissions. Excessive restrictions on fossil fuel imports could jeopardize domestic energy supply security and socio-economic development, while continued expansion would increase carbon emission pressures and hinder the achievement of the dual carbon targets.

The structural contradiction between traditional fossil energy imports and the development of new energy trade makes China need to seek a balance between ensuring energy supply security and promoting low-carbon transition in the process of advancing the green transformation of energy trade, increasing the difficulty of transition.

The advancement of global low-carbon transition has made carbon emission reduction a critical constraint in global energy trade. Low-carbon trade barriers such as the EU Carbon Border Adjustment Mechanism (CBAM), U.S. Clean Energy Standards, and carbon tariffs have been gradually implemented. These barriers, primarily established by developed countries, exhibit significant trade protectionist characteristics for developing nations, exacerbating constraints on China's exports of new energy products and imports of fossil fuels, while increasing the costs and market risks of China's international energy trade.

In terms of new energy product exports, low-carbon trade barriers impose strict requirements on the carbon footprint and low-carbon certification of China's new energy products. Failure to meet these requirements may result in high carbon tariffs, reducing the export competitiveness of China's new energy products. The EU CBAM will be officially implemented in 2026, covering new energy products such as photovoltaic, wind power,

energy storage equipment, and new energy vehicles, requiring imported new energy products to provide full life cycle carbon footprint accounting reports. If the carbon emission intensity exceeds that of EU domestic products, carbon tariffs will be imposed. The United States also plans to introduce carbon tariff policies, setting stringent low-carbon standards for imported new energy products. Although China's new energy industry is rapidly developing, some enterprises still lack comprehensive carbon footprint accounting systems and insufficient low-carbon certification capabilities. The carbon emission intensity of certain new energy products remains higher than that of developed countries. Failure to meet low-carbon trade barrier requirements promptly may lead to the loss of core export markets such as the EU and the United States, severely impacting the development of new energy product exports [23].

Since its launch in 2021, China's carbon market has become the world's largest carbon emission trading market. However, there are still many obstacles in connecting with international carbon markets, making it difficult to achieve cross-border circulation and trading of carbon allowances. This has constrained the integrated development of energy trade and carbon trading, and also reduced China's voice in the global carbon pricing system.

From the perspective of market rules, China's carbon market exhibits significant differences from international carbon markets in terms of trading instruments, pricing mechanisms, and accounting standards. Currently, China's carbon market primarily focuses on the power sector as a pilot program, with trading instruments limited to carbon emission allowances, whereas international carbon markets encompass various instruments such as allowance trading and voluntary emission reduction trading. China's carbon prices are heavily influenced by domestic market supply and demand, remaining at 50–60 yuan per ton in 2023, far below the approximately 80 euros per ton in the EU carbon market, and the pricing mechanism has yet to align with international standards. Although China's carbon emission accounting, reporting and verification (MRV) system has been gradually improved, it still differs from internationally recognized standards,

making it difficult for domestic carbon allowances to gain recognition in the international market [63].

From the perspective of cross-border cooperation, China has not yet established an interconnection mechanism with major international carbon markets, and the cross-border circulation and trading of carbon allowances are strictly restricted. Developed countries such as the EU and the US have dominated the cross-border cooperation rules of the global carbon market, setting high market access thresholds. Due to its relatively short development time and immature institutional system, China's carbon market struggles to integrate into the global carbon market system. Meanwhile, China's Certified Emission Reductions (CCER) projects have low international recognition and are difficult to exchange for international carbon credit products, which restricts Chinese enterprises from offsetting carbon emissions in energy trade through the international carbon market.

The poor integration between domestic and international carbon markets makes it difficult for China to effectively utilize the international carbon market for carbon cost hedging when conducting energy trade, nor can it convert the carbon emission reductions from domestic new energy product exports into international carbon credits. This reduces the low-carbon added value of energy trade and also weakens China's influence in the global carbon pricing system.

The low-carbon transition of China's energy trade is still in its infancy, lacking comprehensive policy, legal, and financial mechanisms to ensure its progress. This has resulted in slow advancement of the low-carbon transition, making it difficult to meet the requirements of global low-carbon trade development.

In terms of policy mechanisms, China has yet to introduce a dedicated low-carbon development plan for energy trade. Existing policies are mostly scattered across sectors such as energy, trade, and environmental protection, lacking systematic and coordination. A low-carbon screening mechanism for fossil fuel imports has not been established, resulting in ineffective constraints on the import of high-carbon-emission fossil fuels. Policies such as carbon footprint certification and low-carbon subsidies for new energy product exports remain incomplete, making it difficult to incentivize enterprises to

enhance the low-carbon competitiveness of new energy products. Relevant policies for integrating energy trade with carbon trading are also lacking, with no clear measures specified for carbon footprint accounting, carbon quota offsetting, or carbon tariff responses [3].

In terms of legal mechanisms, China's laws and regulations related to energy trade and low-carbon development are still incomplete, lacking specialized laws such as the Low-Carbon Trade Law and the Energy Trade Carbon Footprint Management Measures. There is a lack of clear legal norms regarding carbon emission behaviors in energy trade, carbon footprint accounting, and low-carbon certification. Existing laws and regulations provide insufficient provisions for addressing low-carbon trade barriers, leaving enterprises without effective legal remedies when facing carbon tariffs or low-carbon technology barriers. Additionally, intellectual property protection for the export of new energy products is inadequate, with frequent occurrences of infringement on high-end new energy technologies and products, which undermines corporate enthusiasm for technological innovation [55].

In terms of financial mechanisms, China has yet to establish a comprehensive low-carbon financial support system for energy trade, resulting in high financing difficulties and costs for low-carbon energy trade projects. Financial institutions such as banks and securities firms provide insufficient credit support for projects like low-carbon transformation of fossil energy trade and low-carbon upgrading of new energy product exports, lacking targeted low-carbon credit products. The development of carbon financial derivatives markets, including carbon futures and carbon options, remains slow, making it difficult for enterprises to hedge carbon cost risks in energy trade through carbon financial instruments. Green financial products such as green insurance and green funds have limited applications in the energy trade sector, failing to meet the financial needs of enterprises for low-carbon development.

4 Constraints of insufficient discourse power in global energy governance.

Although China has become the world's largest energy consumer, importer, and exporter of new energy products, its voice in the global energy governance system does

not match its energy trade status. It remains passive in energy pricing, rule-making, and institutional participation, severely restricting the high-quality development of China's international energy trade.

China lacks a say in the pricing systems for international fossil fuels such as crude oil, natural gas, and coal, as well as key new energy minerals like lithium, cobalt, and nickel. Energy trade prices are primarily dominated by international markets, facing the dilemma of mismatch between pricing power and import volumes, which increases the cost risks of energy trade [49].

In terms of fossil fuel pricing, international crude oil pricing primarily references futures prices of Brent, WTI, and Dubai crude oil, while natural gas pricing is mainly linked to crude oil prices. Coal pricing is significantly influenced by supply and demand in the international spot market. Although China is the world's largest importer of fossil fuels, it has failed to dominate these pricing systems. Although crude oil futures on the Shanghai International Energy Exchange have been listed for trading, their influence in the international market remains limited, with trading volumes and open interest far below those of Brent and WTI crude oil futures. The use of the renminbi in energy pricing remains low, making it difficult to change the pattern of dollar-dominated energy pricing. China's natural gas futures market has yet to be established, and natural gas import prices are primarily determined by exporting countries, lacking independent pricing capabilities.

In terms of pricing for key minerals in the new energy sector, the international pricing power for minerals such as lithium, cobalt, and nickel is primarily held by traders and financial institutions in developed countries in Europe and America. Although China is the world's largest importer and processor of key minerals, it holds a weak position in pricing negotiations. The international futures markets for key minerals are mainly concentrated in financial centers like London and New York. China has yet to establish a comprehensive futures trading system for key minerals, making it difficult to hedge against price volatility risks through futures markets. The import prices of key minerals are easily manipulated by international capital, significantly increasing production costs for the domestic new energy industry.

Global energy governance rules are primarily formulated by developed countries in Europe and America, which more reflect the interests of developed nations and fail to adequately address the development needs of developing countries. China's participation in the formulation of energy governance rules is relatively low, making it difficult to integrate its own interests and development practices into the rule system.

In terms of traditional fossil energy governance rules, organizations such as the Organization of the Petroleum Exporting Countries (OPEC) and the International Energy Agency (IEA) have dominated the formulation of global rules for crude oil and natural gas production, trade, and reserves. As a cooperative member of the IEA, China has not yet become a core member and lacks voting rights and decision-making power in rule-making. OPEC's decisions are primarily led by Middle Eastern oil-producing countries, making it difficult for China to participate in the formulation of core rules such as production adjustments and pricing mechanisms.

In terms of new energy governance rules, developed countries such as the EU and the US have dominated the formulation of regulations on renewable energy trade, key minerals for new energy, and carbon emission reduction. By establishing technical standards, low-carbon standards, and intellectual property protection rules, they maintain their dominant position in global new energy trade. Although China's participation in the formulation of new energy governance rules has gradually increased, it still remains in a follower position in the development of core rules. For instance, in areas such as global low-carbon certification standards for renewable energy products and trade rules for key minerals for new energy, it is difficult to propose rule proposals that align with the interests of developing countries [49].

In terms of carbon trade rules, developed countries such as the EU and the US have dominated the formulation of rules including the Carbon Border Adjustment Mechanism, carbon credit exchange, and carbon footprint accounting. These rules exhibit distinct trade protectionist characteristics, creating low-carbon barriers to energy trade for developing countries. China lacks a voice in the formulation of carbon trade rules, making it difficult

to promote fairness and inclusiveness in these rules, and thus finds itself in a passive position when dealing with carbon tariffs and low-carbon trade barriers.

Although China has participated in major international energy governance institutions globally, its involvement remains insufficient in depth. It has failed to occupy core positions at the decision-making and executive levels of these institutions, making it difficult to influence their decisions and operations. This has constrained China's ability to play a greater role in global energy governance.

In terms of traditional international energy governance institutions, China mainly participates as an observer and cooperating country in organizations such as the IEA, International Energy Forum (IEF), and World Energy Council (WEC), failing to enter the core decision-making levels of these institutions. Its influence on policy formulation, project implementation, and rule revisions is limited. As for OPEC+, a globally significant oil production coordination mechanism, China has not yet joined, making it difficult to participate in the coordination and regulation of global crude oil production [50].

In terms of emerging international energy governance institutions, organizations such as the Global Energy Interconnection Development and Cooperation Organization and the Asian Energy Forum initiated by China have played a certain role in regional energy governance, but their influence on a global scale remains limited. Compared with traditional institutions like the IEA and OPEC, they lack well-established operational mechanisms, financial support, and international recognition. The energy governance mechanisms of multilateral platforms such as BRICS and the Shanghai Cooperation Organization are still in the construction phase, with incomplete rule systems, making it difficult to form a force that can rival traditional energy governance institutions [50].

5 Technical barriers and market competition pressure facing new energy trade.

Although China's exports of new energy products rank first globally, there are still shortcomings in high-end technologies, brand building, and market layout. It faces technological barriers and intellectual property barriers from developed countries, as well as market competition pressure from emerging economies, severely restricting the upgrading and development of new energy trade [50].

Developed countries such as the EU, the US, and Japan, leveraging their advantages in high-end new energy technologies and core component R&D, have imposed strict technical and intellectual property barriers on China's new energy products, restricting the import of China's new energy products and curbing the international development of China's new energy industry.

In terms of technical barriers, developed countries have established stringent technical standards, quality standards, and low-carbon standards for new energy products. If China's new energy products fail to meet these standards, they will be excluded from their markets. For example, the EU has set strict technical standards for the photoelectric conversion efficiency, durability, and carbon emission intensity of photovoltaic modules, as well as stringent requirements for noise, vibration, and grid connection performance of wind power equipment. The United States has imposed high standards on the range, autonomous driving technology, and battery safety of new energy vehicles. Some China's new energy products struggle to enter the high-end markets of Europe and America due to non-compliance with technical specifications. Meanwhile, developed countries also raise market entry barriers for China's new energy products by establishing technical certification requirements. For instance, the EU's CE certification and the US's UL certification impose high demands on testing procedures and costs for China's new energy products, increasing export costs for enterprises [45].

In terms of intellectual property barriers, enterprises in developed countries hold extensive patent portfolios in core technologies of new energy, restricting the export of China's new energy products through patent infringement lawsuits and collecting patent licensing fees. For example, European and American companies possess core patents in areas such as hetero-junction technology for photovoltaic cells, gearbox technology for wind power equipment, and power battery management systems for new energy vehicles. When exporting related products, Chinese enterprises often face patent infringement lawsuits and are forced to pay high patent licensing fees, severely impacting the export competitiveness of their products. Some developed countries have also strengthened

intellectual property barriers by amending intellectual property protection laws to extend the protection period for new energy patents.

Although China's new energy industry has formed a complete industrial chain, there are still shortcomings in the research and development and production of high-end core components, with a high degree of external dependence, which has become the core bottleneck restricting the export upgrading of new energy products.

In the photovoltaic industry, China, although holding a global dominant position in mid-to-low-end segments such as poly-silicon, silicon wafers, and modules, still relies on imports for core equipment like high-end photovoltaic cells and chips for photovoltaic inverters. For example, coating equipment for photovoltaic hetero-junction cells (HJT) mainly depends on Japanese and German companies, while IGBT chips for photovoltaic inverters are primarily imported from the United States and Europe. The import cost of core components accounts for over 20 % of the production cost of photovoltaic products, not only increasing production costs for enterprises but also exposing them to supply disruption risks [49].

In the wind power industry, China has reached internationally advanced technical levels in aspects such as wind turbine units and blades, but still relies heavily on foreign sources for high-end core components like wind power bearings, control systems, and converters. The main shaft bearings and yaw/pitch bearings for wind turbines primarily depend on companies such as Sweden's SKF and Germany's Schaeffler, while the core chips for wind power converters are mainly imported from Europe and America. The import of core components has constrained the production and export of China's high-end wind power equipment.

In the field of new energy vehicles and energy storage industries, China ranks first globally in production capacity for power batteries and energy storage batteries, but still relies on imports for high-end lithium salts for battery cathode materials, high-end base membranes for battery separators, and energy storage chips. For example, battery-grade lithium hydroxide required for high-nickel ternary cathode materials for power batteries is mainly imported from Chile and Australia, high-end base membranes for battery

separators are primarily sourced from Japan and South Korea, and energy storage chips are mainly imported from the United States and Taiwan, China. The high dependence on foreign core components severely hinders the high-end development of China's new energy vehicles and energy storage equipment [64].

Emerging economies such as India, Brazil, Vietnam, and Malaysia are accelerating the development of the new energy industry. Leveraging advantages like low labor costs and strong policy support, they are engaging in fierce competition with China in the mid-to-low-end new energy product sector. China's new energy products face the risk of having their market share squeezed in emerging markets.

6 Resilience and efficiency of domestic energy trade system need improvement.

Although China's domestic energy trade system has been gradually improved, there are still shortcomings in energy reserves, logistics transportation, market regulation, and corporate competitiveness. The resilience and efficiency of energy trade need to be enhanced, making it difficult to adapt to the profound changes in the international energy trade landscape.

Although China's energy reserve system has been preliminarily established, there are still shortcomings in reserve scale, reserve varieties, and reserve distribution, with limited emergency response capabilities, making it difficult to effectively address risks such as energy supply disruptions and price fluctuations [49].

In terms of reserve scale, China's fossil energy reserves remain below internationally recognized safety standards. Although the strategic crude oil reserve capacity reaches 570 million tons, the reserve days amount to only about 90 days, falling short of the IEA's safety standard of over 90 days, with commercial crude oil reserves being even smaller. The natural gas reserve capacity stands at 30 billion cubic meters, with reserve days of merely around 15 days, far below the 60–90 day reserve levels of European and American countries. While coal reserves are primarily commercial, the emergency reserve scale is insufficient to address the risk of short-term coal supply disruptions. The reserve system for key minerals of new energy has yet to be established,

with reserves of lithium, cobalt, nickel, and other minerals virtually non-existent, exposing them to the risk of resource supply interruptions [49].

In terms of reserve varieties, China's energy reserves are relatively limited, mainly consisting of fossil fuels such as crude oil, natural gas, and coal, while reserves of new energy products and key minerals for new energy are almost non-existent. Among fossil energy reserves, the proportion of high-quality crude oil and special natural gas is relatively low, making it difficult to meet the energy demands of domestic high-end industries.

From the perspective of reserve distribution, China's energy reserves are mainly concentrated in the eastern coastal regions, while major energy-producing and consuming provinces in central and western China lack sufficient reserve facilities, resulting in a mismatch between reserve distribution and energy consumption and transportation patterns. The construction of overseas energy reserve bases lags behind, with no overseas crude oil and natural gas reserve bases established in key energy-exporting regions such as the Middle East, Africa, and Central Asia, making it difficult to ensure the stability of overseas energy supply [24].

Although China's energy logistics and transportation system has been gradually improved, there are still shortcomings in transportation capacity, infrastructure, and multi-modal transport, resulting in low transportation efficiency and high logistics costs, which affect the efficiency and benefits of energy trade.

In the field of fossil fuel logistics transportation, cross-border pipeline capacity for crude oil and natural gas remains insufficient. Key pipelines such as the China-Kazakhstan Crude Oil Pipeline and the China-Russia East Route Natural Gas Pipeline have yet to fully utilize their transportation potential. Maritime logistics face challenges including weak ocean shipping capabilities, low fleet ownership rates for ocean tankers and LNG carriers, and heavy reliance on international shipping companies, resulting in elevated logistics costs. For coal logistics, railway transport capacity is inadequate, with strained railway corridors for west-to-east and north-to-south coal transportation routes. The excessive

reliance on road transport leads to higher logistics costs and increased carbon emission intensity [66].

In terms of logistics transportation for new energy products, products such as photovoltaic modules and wind power equipment are characterized by large size, heavy weight, and susceptibility to damage, which imposes higher requirements on logistics transportation. However, the professional level of logistics transportation for China's new energy products is relatively low, lacking specialized logistics equipment and routes. The maritime logistics capacity for exporting new energy vehicles is insufficient, with a shortage of roll-on/roll-off ships, resulting in long transportation cycles and high costs. The logistics transportation of key minerals for new energy primarily relies on maritime transport, but there is a lack of port handling and storage facilities, leading to low transportation efficiency [66].

In terms of multi-modal transport, China's energy logistics multi-modal transport system is not yet well-established, with poor connectivity between transportation modes such as railways, highways, maritime transport, and pipelines, resulting in low cargo transshipment efficiency. The construction of multi-modal transport information platforms lags behind, leading to lack of transport information sharing and difficulties in achieving full-process tracking and scheduling of goods. Insufficient policy support for multi-modal transport, coupled with the absence of a unified freight pricing system and tax incentives, has resulted in low enthusiasm among enterprises to engage in multi-modal transport.

Although the market supervision mechanism for China's energy trade has been gradually established, there are still shortcomings in the regulatory system, regulatory methods, and international regulatory cooperation. The effectiveness and relevance of market supervision need to be improved, making it difficult to effectively prevent energy trade risks.

From the perspective of the regulatory system, China's energy trade regulation involves multiple departments such as development and reform, energy, customs, taxation, and maritime affairs. The division of regulatory responsibilities among these departments is unclear, leading to overlapping supervision and regulatory vacuums. There is

insufficient coordination between central and local governments in energy trade regulation. Local governments, in pursuit of economic growth, fail to effectively supervise violations by certain energy trade enterprises [64].

From the perspective of regulatory measures, China's energy trade regulation still primarily relies on traditional administrative supervision and on-site inspections, with insufficient application of informatization and intelligent regulatory methods. The information statistical system for energy trade is incomplete, and corporate trade data, logistics data, carbon emission data, and other information lack transparency, making it difficult to achieve precise regulation. The enforcement against illegal activities such as price manipulation, fraudulent trade, and intellectual property infringement in energy trade remains inadequate, with relatively low penalties for violations [64].

From the perspective of international regulatory cooperation, China's regulatory cooperation mechanisms with major energy trading partners remain incomplete, with insufficient international collaboration in areas such as anti-money laundering, counter-terrorism financing, carbon emission regulation, and intellectual property protection. It is difficult to achieve information sharing and law enforcement coordination with energy regulatory agencies in Europe and the United States. When addressing cross-border energy trade risks and low-carbon trade barriers, there is a lack of effective international regulatory cooperation support.

China has a large number of energy trading enterprises, but they are mainly small and medium-sized enterprises. Large leading enterprises have weak international competitiveness and lack advantages in overseas market layout, brand building, and risk management, making it difficult for them to adapt to the fierce competition in global energy trade [66].

In terms of overseas market layout, China's energy trading enterprises have a relatively scattered overseas market presence, lacking systematic and long-term planning, primarily focusing on product exports, with delayed construction of overseas production bases, R&D centers, and logistics centers. In emerging markets such as the Middle East, Africa, and Latin America, companies lack sufficient market research and have

insufficient understanding of local policies, laws, and culture, making it difficult to conduct localized operations.

In terms of brand building, China's energy trade enterprises have relatively low international brand awareness, especially for new energy product companies, which mainly engage in contract manufacturing and private-label production, lacking independent international brands. The enterprises' brand promotion efforts are insufficient, resulting in limited brand influence in the international market and difficulty in competing with well-known brands from Europe, America, and Japan.

In terms of risk management, China's energy trading enterprises have weak risk management capabilities, with insufficient ability to predict and respond to risks such as international energy price fluctuations, geopolitical conflicts, exchange rate volatility, and trade barriers. Enterprises also under utilize risk hedging tools, failing to fully leverage financial instruments like futures, options, and foreign exchange swaps to mitigate risks. As a result, significant losses occur when risks materialize.

Chapter 3 Development prospects and strategic choices of China's international energy trade

3.1 Development prospects of China's international energy trade

Combining global energy development trends, China's national conditions, and the current status of energy trade development, it is predicted that China's international energy trade will exhibit short-term stable supply and risk prevention, as well as medium-to-long-term trends toward greening and diversification. During the short-term phase from 2024 to 2027, the focus will be on ensuring energy supply security, optimizing trade structures, and preventing various risks. In the medium-to-long-term phase from 2028 to 2035, the trade structure will achieve deep greening and high diversification of import sources and export markets, positioning China as a core leader in the global energy trade system [61].

1 Short-term outlook (2024–2027): Stable supply, optimized structure, and risk prevention.

Fossil Energy Imports: Scale stabilizes with structural optimization. Crude oil imports will maintain slight fluctuations, with external dependence remaining around 70 %. Demand structure will further shift toward chemical feed stocks, increasing imports of high-quality and specialty crude oils. Natural gas imports will gradually rebound, raising external dependence to approximately 50 %, while LNG imports will exceed 60%, with sourcing expanding to Russia and Central Asia. Coal imports will stay at reasonable levels, with higher proportions of premium thermal coal and low-sulfur coking coal imports, and imports from neighboring countries surpassing 30 % [55].

New energy product exports: Scale continues to expand with high-end market penetration. Photovoltaic and wind power equipment exports are expected to maintain an annual growth rate exceeding 20 %, while high-efficiency PV modules and large-megawatt wind turbines will account for over 90 % of total exports. Energy storage systems and new energy vehicles are poised for explosive growth, achieving annual growth rates of 50 % and 40 % respectively. The export market for new energy products is

becoming increasingly diversified, with emerging markets in Asia-Pacific, Latin America, and Africa accounting for over 60 % of total exports, while premium products are gradually entering core markets in Europe and the United States.

Energy service trade: Rapid start-up with gradual expansion in scale. Energy technical services and engineering services will achieve rapid growth through Belt and Road energy cooperation, with an average annual growth rate exceeding 30 %; carbon services and energy management services will gradually emerge as new growth points in energy service trade; the market layout of energy service trade will focus on countries along the Belt and Road routes and gradually expand globally [28].

Trade Risk Management: capabilities are progressively strengthening with overall risk control maintained. Diversification of energy import sources and trade routes will effectively mitigate geopolitical risks; enhanced energy reserve systems will bolster emergency response capabilities to address supply disruptions; the gradual maturation of domestic carbon markets coupled with initial alignment with international carbon markets will improve enterprises' resilience against low-carbon trade barriers; energy trading firms are steadily improving risk management capabilities, keeping market risks such as pricing fluctuations and exchange rate volatility under control.

2 Medium-to long-term prospects (2028–2035): green transformation, diversification, and high-end development.

The trade structure has achieved deep green transformation. The proportion of fossil energy imports continues to decline, with natural gas becoming the core category of fossil energy imports, and the share of coal imports falling below 5 %. The export share of new energy products has significantly increased, becoming the core category of China's international energy trade. By 2035, the export value of new energy products is expected to exceed 800 billion dollars, accounting for over 60 % of total energy trade. Energy trade has been deeply integrated with carbon trading, with low-carbon energy trade becoming mainstream. Carbon footprint accounting and carbon quota offsetting have become routine components of energy trade [57].

China's energy imports and export markets exhibit remarkable diversity. The sources of fossil fuel imports have achieved global distribution, with crude oil imports from the Middle East declining below 40 % of total volume. Regions including Russia, Central Asia, Africa, and the Americas now account for over 15 % of imports. New energy products are exported to more than 200 countries and regions worldwide, capturing 40 % of the high-end market in Europe and America while exceeding 50 % in emerging markets such as the Asia-Pacific, Latin America, and Africa. Traditional fossil fuel exporters like the Middle East and Central Asia have become key destinations for China's new energy exports.

Trade categories and models are advancing toward pre-miumization. New energy product exports will transition from mid-to-low-end modules to high-end core components, complete systems, and integrated solutions, with photovoltaic hetero-junction cells, offshore wind power equipment, high-end energy storage systems, and intelligent new energy vehicles emerging as export priorities. Energy service trade will evolve into full-industry-chain integrated services, where integrated solutions encompassing R&D, engineering construction, operation and maintenance, and carbon asset management will dominate the market. Energy trade models are undergoing digital and intelligent transformation, with online transactions, digital settlement systems, and block chain-based traceability becoming primary operational frameworks [25].

China's voice in global energy governance has significantly increased. China will occupy a core position in international energy pricing, rule-making, and institutional participation. Shanghai crude oil futures have become one of the three major global crude oil pricing benchmarks, and the share of the renminbi in energy trade settlements has exceeded 30%. China will lead the formulation of a series of international rules on renewable energy trade, key minerals for new energy, and carbon trading, becoming a core participant in global energy governance rule-making. The emerging energy governance institutions initiated by China will complement traditional institutions, promoting the development of the global energy governance system toward fairness, justice, and inclusiveness.

China's international energy trade is undergoing a structural transformation driven by the imperatives of energy security, the national dual carbon targets (peaking emissions before 2030 and achieving carbon neutrality by 2060), and the country's growing technological leadership in clean energy manufacturing. As the world's largest energy consumer and importer, China has historically relied on massive inflows of crude oil, natural gas and coal. The development prospects of its energy trade will be shaped by a gradual decoupling from fossil fuel imports and a parallel expansion of high-tech low-carbon exports, redefining its role in global energy markets.

In the medium term, crude oil imports are expected to plateau and begin a slow decline after 2030. This trend reflects the rapid electrification of road transport, tightened fuel economy standards and the scaling up of domestic refining capacity geared toward petrochemicals rather than transport fuels. Nevertheless, China will remain a dominant crude buyer for the next decade, continuously diversifying supply sources through strategic partnerships with Middle Eastern producers, Russia, and Central Asian states. Natural gas imports, by contrast, are projected to grow further as gas serves as a bridge fuel in the power and industrial sectors. Pipeline imports from Russia (via the Power of Siberia and its planned extensions), Central Asia and Myanmar will be complemented by expanding liquefied natural gas (LNG) regasification infrastructure along the coast, although the pace of growth will be moderated by the cost competitiveness of renewables and energy security considerations that favour domestically produced alternatives. Coal imports, after their recent surge linked to post-pandemic recovery and hydropower shortfalls, are widely expected to fall structurally as renewable capacity additions and improved grid integration displace coal-fired generation.

The most dynamic element of China's future international energy trade lies in the export of clean energy technologies. China currently dominates global supply chains for solar photovoltaic modules, wind turbines, lithium-ion batteries and electrolyzers. Its enterprises are scaling up overseas sales of these products, effectively exporting embodied energy equipment that enables decarbonisation in importing countries. Electric vehicle exports represent a parallel channel, with Chinese manufacturers increasingly supplying

battery-electric and plug-in hybrid vehicles to Europe, Southeast Asia and Latin America. This transforms the traditional energy trade model from one centred on resource extraction and combustion to one based on the provision of hardware and intellectual property for energy transition.

Geoeconomic dimensions reinforce these prospects. The Belt and Road Initiative is pivoting from fossil fuel project financing toward green energy infrastructure, cross-border electricity interconnections and energy efficiency investments. China's active participation in international standard-setting for green hydrogen, carbon accounting and new energy technologies will further facilitate market access and shape future trade rules. Regional power grid integration with neighbouring countries, though still modest, offers additional opportunities for electricity exports and balancing renewable intermittency.

In sum, the development prospects of China's international energy trade are defined by a dual trajectory: a gradual reduction in fossil fuel import dependency, particularly in oil and coal, while selectively expanding natural gas sourcing, and a vigorous rise in technology-driven exports of renewable energy systems and electrified transport. This transition not only enhances domestic energy security but also positions China as an indispensable actor in global decarbonisation, transforming its external energy linkages from a net material importer into a hub for low-carbon technology dissemination and climate-aligned trade.

3.2 Strategic path to building a safe, resilient and green international energy trade system for China

To achieve the short-term and medium-to-long-term development prospects of China's international energy trade, it is essential to focus on ensuring energy security, promoting green transition, and enhancing global discourse power. This requires building a secure, resilient, and green China international energy trade system through six key aspects: optimizing trade structure, diversifying layouts, strengthening supply chain resilience, improving industrial competitiveness, participating in global energy governance,

and perfecting domestic support systems [16]. Figure 3.1 shows China energy trade development trend forecast.

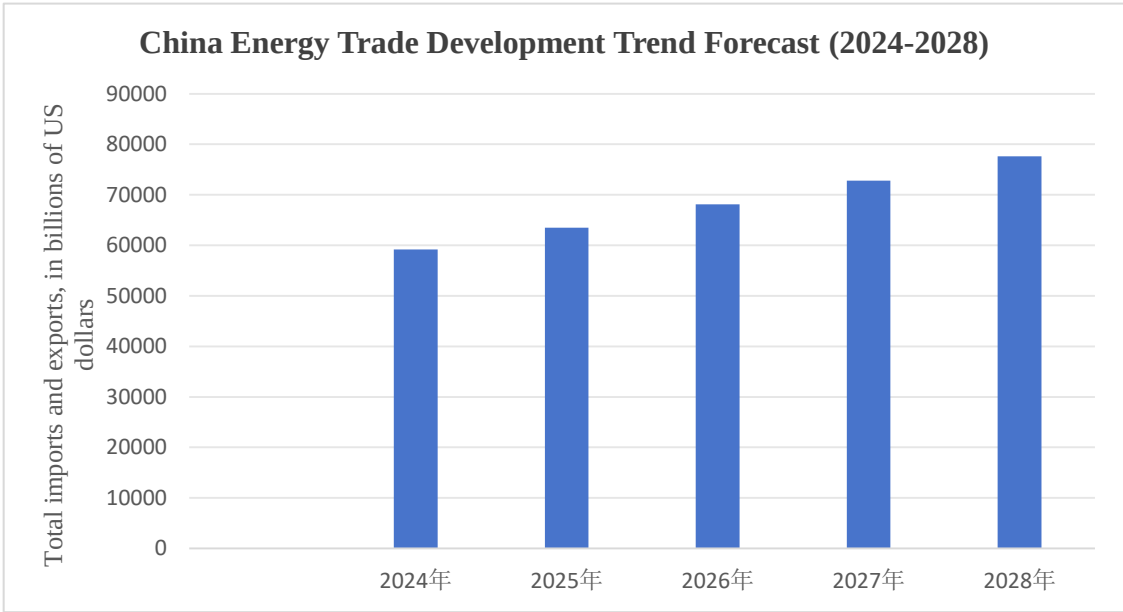


Figure 3.1 – China energy trade development trend forecast (2024–2028) [10]

1 Optimize the energy trade structure and promote the green and low-carbon transition of trade.

Promote the optimization of fossil energy import structures. Establish a low-carbon screening mechanism for fossil energy imports, restricting the import of high-carbon-emission and low-quality fossil fuels while encouraging imports of premium crude oil, specialty natural gas, and low-sulfur coking coal. Shift crude oil import demand toward chemical feed stocks, supporting refineries' transition to integrated chemical production to enhance value-added utilization and low-carbon efficiency. Expand natural gas imports with a focus on LNG imports, diversify import sources, and leverage natural gas as a transitional energy source during the energy transition.

Accelerate the export upgrading of new energy products. Relying on new energy technology innovation, promote the high-end and intelligent upgrading of products such as photovoltaic, wind power, energy storage, and new energy vehicles, enhance the independent production capacity of high-end core components, and reduce dependence on

foreign sources; cultivate international brands for new energy products, support enterprises in obtaining international certifications and brand promotion, and improve the international visibility and market recognition of China's new energy products; expand the trade categories of new energy products, accelerate the research, development, and export of emerging new energy products such as hydrogen energy equipment, biomass energy equipment, and geothermal energy equipment, and promote the transformation of new energy trade from equipment export to equipment + technology + service export [8].

Foster new growth points in energy service trade. Vigorously develop energy technology services, promoting the international export of new energy technologies such as photovoltaic, wind power, and energy storage, as well as low-carbon technologies like clean coal utilization and CCUS; strengthen energy engineering services by leveraging China's infrastructure advantages to undertake global energy infrastructure construction projects, and provide integrated services for cross-border energy pipelines, new energy power stations, and LNG receiving terminals; accelerate the development of carbon services, offering overseas enterprises carbon footprint accounting, carbon trading, and carbon asset management services, and promote the deep integration of energy service trade and carbon trading.

Promote the integrated development of energy trade and carbon trading. Improve the carbon footprint accounting system for the export of new energy products, establish low-carbon certification standards in line with international standards, and promote the international recognition of China's carbon footprint certification; facilitate the inter-connectivity between domestic and international carbon markets, explore cross-border circulation and trading of carbon allowances, and encourage enterprises to utilize international carbon markets to hedge carbon cost risks; incorporate carbon emission reductions into the value-added accounting of new energy product exports, transform the carbon emission reductions brought by new energy product exports into international carbon credits, and enhance the low-carbon value-added of energy trade [16].

2 Expand diversified layouts to mitigate geopolitical and market risks.

We will promote diversification of fossil fuel import sources. Efforts will be made to further reduce dependence on crude oil imports from the Middle East by expanding imports from Russia, Central Asia, Africa, and the Americas. Natural gas import sources will be diversified, with a focus on strengthening pipeline gas cooperation with Russia and Central Asia, while increasing LNG imports from Qatar, the United States, and Mozambique. Coal import sources will be optimized by expanding imports from neighboring countries such as Russia, Mongolia, and Kazakhstan, while reducing reliance on Indonesia and Australia [2].

Achieve diversification of export markets for new energy products. Consolidate high-end markets such as Europe and North America, promote the entry of high-end new energy products into core markets in Europe and America to meet their stringent technical and low-carbon standards; deepen engagement in emerging markets such as Asia-Pacific, Latin America, and Africa, leveraging the Belt and Road energy cooperation to facilitate localized production and sales of new energy products in these markets; expand into traditional fossil fuel export markets such as the Middle East and Central Asia, seize opportunities for energy transition, and promote exports of new energy products like photovoltaic and wind power to achieve a global export market layout.

Promote diversification of energy trade routes. Enhance the dual-faceted fossil energy infrastructure featuring maritime transport and pipelines, accelerate cross-border pipeline projects including the China-Russia West Route Natural Gas Pipeline and Phase III of the China-Kazakhstan Crude Oil Pipeline, while boosting land transportation capacity. Optimize maritime routes by establishing new shipping corridors such as the Arctic shipping route and China-Pakistan Economic Corridor, reducing dependence on the Strait of Malacca. Develop overseas energy ports and LNG receiving terminals to strengthen maritime route security and resilience. Improve logistics networks for renewable energy products through specialized distribution systems, optimize coordination among maritime, air, and land transport, and establish overseas warehouses and logistics hubs in key markets including Europe, America, and the Asia-Pacific region [33].

3 Strengthen supply chain resilience and enhance emergency response capabilities for energy trade.

Enhance the energy reserve system. Expand fossil fuel reserves by increasing crude oil strategic reserves to over 120 days and natural gas reserves to over 60 days, while raising the proportion of high-quality crude oil and specialty natural gas reserves. Optimize energy reserve distribution by constructing storage facilities in major energy-consuming provinces in central and western China to align with regional energy consumption and transportation patterns. Accelerate the development of overseas energy reserve bases by establishing crude oil and natural gas storage facilities in key energy-exporting regions such as the Middle East, Africa, and Central Asia. Establish a strategic reserve system for critical minerals in new energy sectors, expanding reserves of lithium, cobalt, nickel, and other minerals to ensure resource supply for the renewable energy industry [65].

Enhance energy logistics transportation efficiency. Strengthen energy logistics infrastructure development, boost cross-border energy pipeline capacity, increase the fleet size of ocean tankers, LNG carriers, and roll-on/roll-off ships for new energy products, optimize coal railway transport corridors, and reduce road transport reliance. Improve multi-modal transport systems by ensuring seamless integration of rail, road, maritime, and pipeline transport modes. Establish a national energy logistics information platform to enable real-time data sharing and end-to-end tracking. Promote green and intelligent energy logistics through widespread adoption of new energy vehicles and application of AI and IoT technologies to optimize logistics scheduling, reduce operational costs, and lower carbon emissions.

Establish a supply chain risk early warning and response mechanism. Develop a global energy supply chain risk monitoring system utilizing big data and artificial intelligence technologies to conduct real-time surveillance and precise forecasting of risks such as geopolitical conflicts, energy price volatility, and trade barriers. Implement an emergency response framework for energy supply chains by formulating contingency plans for supply disruptions and logistics disruptions, while enhancing emergency

cooperation with major energy trading partners. Encourage energy trading enterprises to employ financial instruments like futures contracts, options, and foreign exchange swaps to hedge against market risks including price fluctuations and exchange rate volatility, thereby strengthening corporate risk management capabilities.

4 Enhance the competitiveness of the new energy industry and break through technological and trade barriers.

Increase investment in new energy technology R&D. Establish a national special fund for new energy technology R&D to prioritize support for core technologies such as photovoltaic hetero junction batteries, offshore wind power equipment, high-end energy storage chips, and power battery management systems for new energy vehicles. Promote deep integration of government, industry, academia, research institutions, and application sectors by encouraging universities, research institutes, and enterprises to collaborate in establishing R&D platforms, thereby accelerating the industrial application of new energy technologies. Strengthen fundamental research in new energy technologies to enhance original innovation capabilities and break through technological monopolies held by developed countries [18].

Improve the new energy industry chain and supply chain. Leveraging the industrial chain advantages of China's new energy sector, strengthen collaborative efforts among upstream and downstream enterprises to promote chain supplementation, strengthening, and extension in photovoltaic, wind power, energy storage, and new energy vehicle industries; enhance the independent production capacity of high-end core components, achieving domestic substitution for key components such as photovoltaic inverter chips, wind power bearings, energy storage chips, and new energy vehicle IGBT chips; intensify exploration, development, and processing utilization of critical mineral resources for new energy, promote cooperative development of overseas key mineral resources, and ensure resource supply for the industrial chain and supply chain.

Actively address technological and trade barriers. Promote the alignment of China's new energy technology standards and low-carbon standards with international norms, participate in the formulation of international standards, and enhance the recognition of

China's standards in the international market; strengthen the international certification capacity building for new energy products to reduce corporate certification costs; establish intellectual property protection and rights enforcement mechanisms, encourage enterprises to engage in overseas patent layout, and counter intellectual property barriers from developed countries; enhance trade cooperation with emerging economies through free trade agreements, reduce trade tariffs on new energy products, and jointly address trade protectionism from developed countries.

5 Deeply engage in global energy governance to enhance international discourse power and influence

Strive for international energy pricing power. Strengthen the Shanghai International Energy Exchange, enhance the international influence of crude oil futures, promote the listing of futures varieties such as natural gas, coal, and key mineral resources for new energy, and build a China-owned energy pricing system; promote the use of the renminbi in energy trade pricing and settlement, expand the application of the Cross-border Inter bank Payment System (CIPS) in energy trade, sign local currency settlement agreements with major energy trading partners, and reduce reliance on the US dollar; strengthen the linkage between energy futures markets and spot markets to improve the effectiveness and rationality of market pricing.

Lead the formulation of international energy governance rules. Actively participate in the establishment of global energy governance rules, and propose energy trade, carbon emission reduction, and new energy governance rules that align with the interests of developing countries at multilateral platforms such as the G20, BRICS, and Shanghai Cooperation Organization; take the lead in formulating international rules on renewable energy trade, development of key minerals for new energy, carbon footprint accounting, and carbon credit exchange, integrating China's industrial advantages and development practices into the rule system; promote fairness and inclusiveness in global energy governance rules, adhere to the principle of common but differentiated responsibilities, and encourage developed countries to provide financial and technical support to developing countries to facilitate their energy transition.

Enhance the participation of international energy governance institutions. Promote China to become a core member of traditional energy governance bodies such as the IEA and OPEC+, participating in their key decision-making and rule-making processes; strengthen emerging energy governance institutions initiated by China, including the Global Energy Interconnection Development and Cooperation Organization and the Asian Energy Forum, improve their operational mechanisms, expand financial support, and enhance international recognition; strengthen the energy governance mechanisms of multilateral platforms such as BRICS and the Shanghai Cooperation Organization, build a regional energy trade community, promote the unification and coordination of regional energy governance rules, and form a counterbalance to traditional energy governance institutions [27].

Strengthen international energy cooperation and exchanges. Deepen cooperation with traditional energy exporters such as Russia, Central Asia, and the Middle East, promote the integration of fossil energy trade and new energy cooperation to achieve diversified energy collaboration; enhance energy technology cooperation with developed countries like the EU and the US, conduct joint research and development in areas such as CCUS, hydrogen energy, and energy storage, and facilitate international sharing of technologies; strengthen energy trade cooperation with emerging economies through capacity cooperation, technology transfer, and financial support to drive their energy transition and expand China's circle of friends in global energy trade [59].

6 Improve the domestic support system to provide guarantees for energy trade development.

Improve the energy trade policy system. Issue a dedicated China International Energy Trade Development Plan (2025–2035) to clarify the development goals and pathways for green, diversified, and high-end energy trade; refine supportive policies for energy import diversification, upgrading exports of new energy products, and development of energy service trade, including tax incentives, fiscal subsidies, and financial support; formulate low-carbon development policies for energy trade, establish a low-carbon screening mechanism for fossil energy imports, and improve carbon footprint certification

and low-carbon subsidy policies for new energy product exports; introduce policies to address low-carbon trade barriers, establish a carbon tariff hedging mechanism, and support enterprises in enhancing low-carbon competitiveness.

Refine energy trade legislation and regulations. Expedite the enactment of specialized laws including the Energy Trade Law and Low-Carbon Trade Law to clarify fundamental principles, market access requirements, regulatory frameworks, and low-carbon standards for energy trade. Strengthen legal provisions on intellectual property protection, anti-monopoly measures, and anti-unfair competition in energy trade, intensify enforcement against infringement, and increase penalties for violations. Develop international cooperation frameworks to standardize overseas energy investments, trade activities, and engineering projects, safeguarding corporate rights abroad. Enhance legal mechanisms to address international trade barriers and provide enterprises with effective legal remedies [50].

Establish a financial support system for energy trade. Enhance credit support for energy trading enterprises by encouraging banks to develop targeted financial products such as low-carbon loans and export credit facilities to reduce corporate financing costs. Develop carbon financial markets by introducing carbon derivatives including futures contracts, options, and funds to provide enterprises with carbon cost hedging tools. Support energy trading companies in utilizing capital markets for financing through encouraging listings and bond issuance. Improve the export credit insurance system by expanding coverage for new energy products and energy engineering services, thereby mitigating overseas market risks for businesses.

Enhance regulatory oversight in the energy trade market. Refine the energy trade supervision framework by clarifying the responsibilities of relevant departments including development and reform commissions, energy authorities, customs, and tax authorities, eliminating regulatory overlaps and gaps while strengthening coordination between central and local governments. Promote digital and intelligent transformation of energy trade regulation through establishing a national energy trade supervision information platform that integrates corporate data on trade activities, logistics operations, and carbon emissions

to enable precision monitoring. Intensify enforcement against illegal practices such as price manipulation, fraudulent transactions, and intellectual property infringements in energy trade to increase penalties. Strengthen regulatory cooperation with major energy trading partners by establishing mechanisms for information sharing and joint law enforcement to collectively address cross-border energy trade risks [54].

Cultivate internationally competitive energy trade leaders. Support energy trading enterprises in mergers and acquisitions to foster large-scale industry leaders integrating energy trading, logistics, warehousing, finance, and risk management. Encourage these leaders to expand overseas markets by establishing production bases, R&D centers, and logistics hubs for localized operations. Assist industry leaders in strengthening brand development through international marketing campaigns to enhance global brand recognition. Promote risk management capabilities by enhancing market risk forecasting and response strategies, utilizing financial instruments for risk hedging, and positioning them as key players in global energy trade.

Conclusion

This master thesis is set against the backdrop of deepening global energy transition, restructuring of geopolitical patterns, and the advancement of China's dual carbon goals, with China's international energy trade as the research object. By examining the macro background of global energy trade development, it analyzes the current status, driving factors, and core challenges of China's international energy trade, forecasts short-term and medium-to-long-term development prospects, and ultimately proposes a strategic path to build a secure, resilient, and green China international energy trade system, leading to the following core conclusions:

Global energy trade is undergoing profound changes, characterized by continuous growth in scale, structural transition toward cleaner energy, multi-polar regional patterns, and rule restructuring toward low-carbon models. Global energy transition, geopolitical competition, and the restructuring of energy governance systems have become core factors influencing the global energy trade landscape. These developments have brought new energy trade opportunities and regional energy cooperation opportunities for China's international energy trade, while also posing challenges such as geopolitical risks and low-carbon trade barriers.

China's international energy trade has transformed from a single fossil energy importer to a dual-core participant in both fossil energy imports and new energy product exports, with trade scale continuously expanding and structure constantly optimizing. The scale of fossil energy imports has stabilized, crude oil demand has shifted toward chemical feed stocks, a diversified pattern of natural gas imports has gradually taken shape, and coal imports have continued to decline due to domestic production capacity expansion. New energy product exports have grown rapidly, with photovoltaic and wind power equipment exports ranking first globally, while energy storage devices and new energy vehicles have become new export growth points. Energy service trade has gradually emerged as a new complement to trade. The sources of imports and trade channels have diversified, and their influence in the global energy trade landscape continues to rise.

The development of China's international energy trade is driven by a synergy of four major factors: domestic, international, technological, and institutional aspects. Endogenous drivers include high-quality domestic economic growth, the advancement of the dual carbon goals, structural shortages in energy supply, and industrial structure optimization and upgrading. External opportunities arise from global energy transition, the deepening of the Belt and Road initiative, the diversification of the global trading system, and the restructuring of energy governance systems. Core support comes from breakthroughs in fossil energy extraction and transportation technologies, new energy technologies, energy digitalization technologies, and low-carbon technologies. Institutional safeguards are provided by domestic energy trade policies, institutional innovations, and the establishment of international energy cooperation mechanisms. Driven by these multiple factors, China's international energy trade holds tremendous potential in areas such as upgrading fossil energy imports, exporting high-end new energy products, scaling up energy service trade, deepening regional energy cooperation, and integrating energy trade with carbon trading.

China's international energy trade development faces a series of core challenges: geopolitical conflicts exacerbate supply chain security risks, concentrated energy import sources, single trade routes, severe price fluctuations, and intensified Western sanctions and trade protectionism; structural contradictions exist between traditional fossil fuel imports and the development of new energy trade during the low-carbon transition, with low-carbon trade barriers becoming increasingly prominent, poor connectivity between domestic and international carbon markets, and insufficient mechanisms to ensure low-carbon transition; China lacks sufficient influence in global energy governance, being in a passive position in international energy pricing, rule-making, and institutional participation; new energy trade faces technological and intellectual property barriers from developed countries, with high dependence on foreign high-end core components and increasing market competition pressure from emerging economies; the resilience and efficiency of China's domestic energy trade system need improvement, with inadequate

energy reserves, logistics transportation, market supervision systems, and weak international competitiveness of enterprises.

The development prospects of China's international energy trade show a trend of stable supply, optimized structure, and risk prevention in the short term, as well as greening, diversification, and high-end upgrading in the medium to long term. During the short-term phase from 2024 to 2027, the scale of fossil energy imports will stabilize with structural optimization, exports of new energy products will continue to grow, energy service trade will take off rapidly, and trade risks will remain generally controllable. In the medium to long-term phase from 2028 to 2035, the trade structure will achieve deep greening, exports of new energy products will become core categories, import sources and export markets will be highly diversified, trade categories and models will upgrade to higher-end levels, and China's voice in global energy governance will significantly increase.

To build a safe, resilient, and green international energy trade system for China, it is essential to focus on ensuring energy security, promoting green transformation, and enhancing global discourse power as core objectives, while implementing six strategic approaches: optimizing the energy trade structure to drive green and low-carbon trade transformation; diversifying layouts to mitigate geopolitical and market risks; strengthening supply chain resilience to improve emergency response capabilities in energy trade; boosting the competitiveness of the new energy industry to break through technological and trade barriers; deeply engaging in global energy governance to enhance international discourse power and influence; and improving domestic support systems to provide safeguards for energy trade development in terms of policies, laws, finance, regulation, and enterprise cultivation.

This study addresses the shortcomings of existing systematic research on China's international energy trade by establishing a comprehensive research framework encompassing global context – China's current situation – driving factors – core challenges – development prospects – strategic pathways, providing theoretical support and practical guidance for the high-quality development of China's international energy trade. However,

due to limitations in research level and data availability, this paper still falls short in terms of the depth of quantitative analysis and the representative of case studies. Future research could further strengthen data collection and organization to build empirical models quantifying the impact of various factors on China's international energy trade; expand the coverage of case analyses to include more regions and energy categories; and refine implementation measures for strategic pathways to enhance their operability. In the future, as China's energy transition continues to advance and the global energy governance system gradually restructures, China's international energy trade will achieve higher-quality development, contributing greater China's strength to safeguarding national energy security, promoting global energy transition, and building a community with a shared future for mankind.

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