The analysis of the potential through the Mode Change of transport from Road to Waterway

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Abstract: In 2015, the Chinese government committed to reducing all greenhouse gas emissions, to reach the peak of carbon dioxide before 2030 and carbon neutrality by 2060. Transport accounts for a large share of global greenhouse gas emissions, so greener and low-carbon transport is an important part of achieving the two-carbon goal. Although many researches have examined carbon emissions from the transport sector, few have analyzed the potential for carbon reduction from the perspective of optimizing the transport structure. Based on the analysis and prediction of the logistics system of goods transportation in Zhejiang Province, the potential of changing the mode of transport from road to waterway for CO2 emission reduction is further analyzed. The results show that the implementation of a "mode change of transport from road to waterway" can better reduce the carbon emissions in the field of transportation, to provide a theoretical basis for the energy conservation and emission reduction targets in the field of transportation in Zhejiang Province.

1. Introduction

The Party Central Committee and the State Council attach great importance to addressing climate change. In December 2021, the Central Committee of the Communist Party of China and the State Council issued the "Opinions on Deepening the Battle of Pollution Prevention and Control", which focused on energy, industry, urban-rural construction, transportation and other fields, as well as steel, non-ferrous metals, building materials, petrochemical and chemical industries, to carry out carbon peak activities in depth.

The transportation industry is a leading and fundamental industry for the development of the national economy and has always been a key area in addressing climate change. Research shows that CO2 emissions in the transportation sector account for about 11% of the total social emissions, and the main driver of transportation carbon emissions is road transportation. According to the "China Mobile Source Environmental Management Annual Report (2020)", greenhouse gas emissions from roads, waterways, civil aviation, and railways are about 6.9, 0.7, 0.5, and 0.1 billion tons of carbon dioxide equivalent, accounting for 84.1%, 8.5%, 6.1%, and 1.2%. Promoting transportation structure adjustment is an important way to achieve carbon peak in the transportation field. In December 2021, the General Office of the State Council issued the Work Plan for Promoting the Development of Multimodal Transport, Optimizing and Adjusting the Transportation Structure (2021-2025), which proposed to promote the "transit of Commodity from the public to the railway and from the public to the water", and formed a development pattern of railway and waterway based long-distance transportation of bulk goods and containers [4]. In June 2022, the Office of the Leading Group of Zhejiang Province, a strong transportation province, issued the "Implementation Plan for Carbon Peak in the Transportation Field of Zhejiang Province", proposing to carry out a concentrated campaign of "public transportation to water" for bulk goods and medium to long-distance goods.

Therefore, based on the development status of waterway transportation in Zhejiang Province, this paper comprehensively analyzes the potential of " mode change of transport from road to waterway (MCRW)" in cargo transportation, calculates the emission reduction benefits of MCRW in cargo transportation in the province, and formulates specific implementation paths. It provides technical solutions for the adjustment of the transportation structure in Zhejiang Province and provides strong support for the green and low-carbon transformation of transportation and the construction of a high-level transportation province.

This paper aims to analysis the potential of the mode change from road to waterway transport. The rest of this manuscript is structured as follows. Section 2 reviews the literature on CO2 emission in the transport sector including road and waterway. The analysis of the development status of waterway transportation is proposed in Section3. Section 4 analysis the potential of MCRW in the perspective of four types of transport cargo. The conclusions are summarized in Section 5.

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2. Literature review

In the past few decades, with the increasing impact of greenhouse gases, academia and industry have conducted many studies on carbon dioxide emissions reduction in transportation. For example, [6] proposed a method for calculating transportation related carbon dioxide emissions in European tourist cities. [8] proposed an innovative model to predict the potential benefits of carbon dioxide emissions trading in transportation in China. [2] introduced a marginal emission reduction cost curve to identify the connections between all transportation modes, providing a decision-making basis for estimating the cost and potential of reducing carbon dioxide emissions in China's transportation sector.

The research on carbon reduction in the field of highways is also an important part. [1] used the LMDI method to analyze the impact of various influencing factors on carbon emissions reduction, providing feasibility for China to achieve its strategic goals of carbon peaking and carbon neutrality. [3] analyzed the current carbon reduction potential of China's road transportation and found that short-term carbon reduction should focus more on the quantity and structure of transportation, while long-term carbon reduction should focus more on the application of new technologies in the field of highways.

Waterway transportation is also one of the key research directions in the field of transportation. [5] developed a new model to study the relationship between ship speed and carbon emissions from the perspective of the offshore supply chain, and applied the research results to simulate the flow direction of container traffic. [9] analyzed the efforts made by the shipping industry in carbon reduction, providing a scientific basis for achieving global greenhouse gas emissions reduction,

In addition to the research specifically focused on carbon emissions in the fields of waterways and highways mentioned above, there are also some experts and scholars who pay more attention to the carbon emission relationships between different modes of transportation. [7] conducted a comparative analysis of carbon emissions from road, transportation, and waterway transportation. The analysis results showed that the process of converting goods from road transportation to waterway transportation significantly reduces carbon dioxide emissions in the transportation sector. Moreover, through the implementation of a series of policies, this model transformation has great potential. [10] first analyzed the influencing factors of carbon emissions using the LMDI method. The analysis results showed that the optimization of transportation structure has huge implementation space and can reduce carbon emissions to a certain extent. The results confirm that effective changes in traffic structure can help reduce CO2 emissions

3. Analysis of the development status of waterway transportation

In 2008, the per capita GDP of Zhejiang Province exceeded 6000 US dollars, entering the late stage of industrialization development. Throughout developed countries such as the United States, Germany, and France, the demand for transportation of goods during this period showed typical characteristics of increasing scale, slowing down the growth rate, prioritizing highways, and decreasing water transportation. The scale of cargo transportation in our province has increased from 84.6 million tons in 1978 to 3.27 billion tons in 2021, with a growth rate of 10.4% before 2000 to 6.1% after 2010. The proportion of highways has increased from 31.8% to 65.3%, and the proportion of waterways has decreased from 51.5% to 33.4% (including sea transportation).

Since 2018, Zhejiang Province has begun a three-year transportation structure adjustment action. In 2018 and 2019, the growth rate of waterway freight volume and cargo turnover was higher than that of roads, especially in 2018, the freight volume and cargo turnover of waterways were respectively 4% and 8% higher than that of roads, and the results were remarkable. But on the whole, the transport structure has not changed fundamentally. Details can be seen in Fig. 1 to Fig.4.

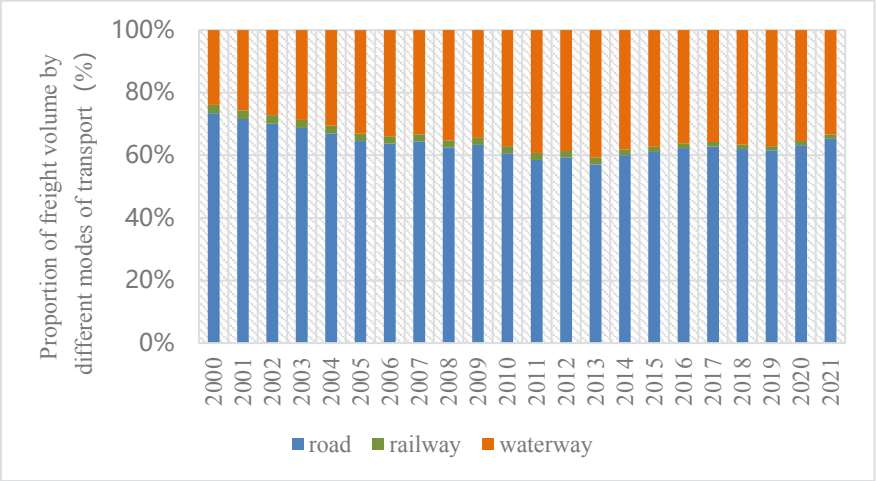

Fig.1 Structural change of freight volume in Zhejiang Province

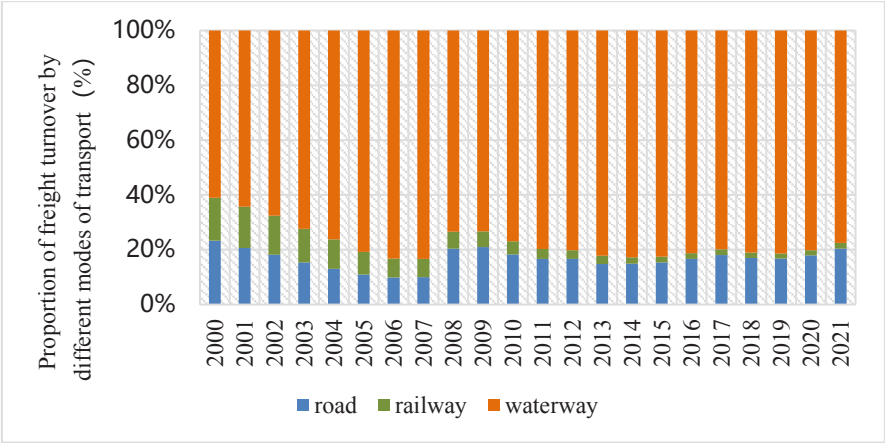

Fig.2 Structural change of cargo turnover in Zhejiang Province

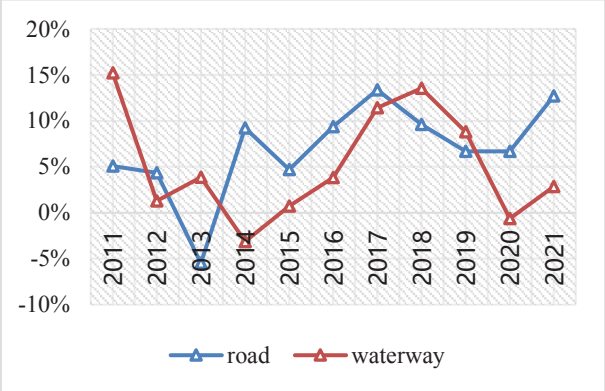

Fig.3 Annual growth rate of freight volume by transport mode

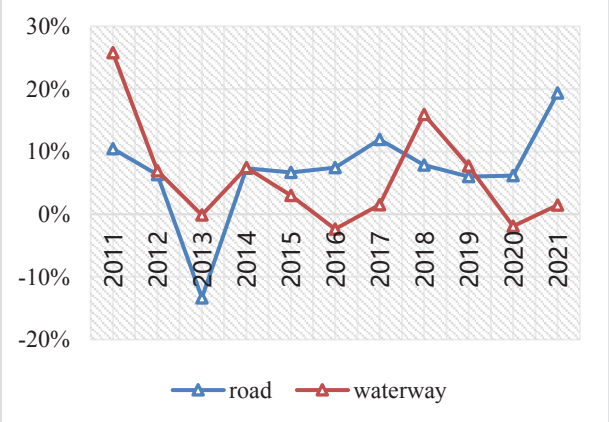

Fig.4 Annual growth rate of freight turnover by transport mode

Overall, in recent years, the demand for water transportation in Zhejiang province has stabilized, and the scale of water transportation has maintained stable growth. Specifically, with the advancement of industrialization, the growth rate of inland waterway transport has gradually slowed down. In 2021, the province completed the inland cargo transport of 250 million tons and a cargo turnover of 37.54 billion tonne-kilometres, and the cargo scale is expected to reach the plateau in 2030. Coastal freight has maintained a rapid growth trend, in recent years, affected by the epidemic and the international situation, the growth rate is also slowing down. In 2021, the province will complete 820 million tons of coastal cargo transport and 879.56 billion tonne-kilometres of cargo turnover, which is expected to reach about 1 billion tons in 2025. The demand for ocean freight is greatly affected by global economic conditions and other uncertainties. In recent years, ocean freight in Zhejiang province has shown a downward trend after a downward trend, but it has also shown a downward trend under the influence of the entire shipping market.

China's industrialization will be fully completed around 2030, and then enter the post-industrialization stage, and economic development will shift from the high-speed growth stage to the high-quality development stage. It is expected that before 2030, the overall trend of waterway transportation in the province will continue to maintain growth will not change, and the growth rate will continue to slow down, and then it will maintain overall stability at a certain scale, with certain annual fluctuations. Among them, ocean freight is synchronized with global economic development, and the growth of inland water transportation mainly depends on the adjustment of transportation structure.

4. Analysis of the potential of MCRW

Coal, building materials (cement, etc.), containers, oil products, natural gas, iron ore, grain and agricultural products, express delivery, less-than carloads and hazardous chemicals and other ten types of cargo constitute the main part of cargo transport in Zhejiang Province, accounting for about 60% of the total social freight volume in our province. In 2019, through the analysis of the current situation and trend of the transport logistics of the ten major cargo types, it was clear that the cargo types with the potential of MCRW in Zhejiang province were concentrated in the four categories of coal, cement, grain and container, and the potential of MCRW research and analysis was carried out for the above cargo types.

4.1 Analysis of coal transport logistics

4.1.1 Analysis of the potential of MCRW of coal transport

The coal in Zhejiang province mainly flows into the province from outside the province and from east and north of Zhejiang. Since 2013, Zhejiang province has officially

withdrawn from the field of coal production, and all coal demand has been transferred from outside the province and overseas, and coastal and inland ports have become the main nodes of coal into Zhejiang. From the regional distribution of coal throughput in our province, the coal throughput in eastern and northern Zhejiang regions will account for nearly 85% of the province in 2021, mainly completed by Jiaxing Port, Ningbo Zhoushan Port, Wenzhou Port and other ports, details can be seen in Table 1.

Table 1 Coal throughput and growth rate of major ports in 2021

Port	Coal throughput (tons)	Two-year average growth rate (%)
NingboZhoushan Port	2500	8.0
Jiaxing Port	3524	1.5
Wenzhou Port	1145	6.4

4.1.2 Prediction of transfer volume from MCRW

Combined with the historical trend and existing planning requirements, the future change trend of coal consumption in the province is estimated, and as the basis for predicting the change trend of the total coal transportation of major ports in the future, it is assumed that the total coal transportation of all ports in 2025 and 2030 will decrease simultaneously according to the declining trend of coal consumption in the province (see Table 2 for details).

Table 2 Forecast of coal consumption in the whole province

Year	Forecast of coal consumption in the province (10,000 tons)	Decrease from 2021 (%)
2020	13100	-
2021	12920	-
2022	12760	-
2023	12620	2.32
2024	12500	3.25
2025	12400	4.02
2026	12310	4.72
2027	12230	5.34
2028	12160	5.88
2029	12090	6.42
2030	12020	6.97

Based on the overall trend of decreasing coal consumption year by year in Zhejiang province, the potential of coal MCRW in the future is mainly predicted based on the expected growth of the waterway traffic of Ningbo Zhoushan Port, Jiaxing Port and Wenzhou Port in the target years (2025, 2030), combined with the natural decline rate of waterway traffic. The specific algorithm is as follows:

Coal MCRW potential of each port = predicted value of coal waterway transportation in target year - coal waterway transportation in base year + natural decline of coal waterway transportation in base year = coal throughput in target year × water transportation ratio in target year - coal throughput in base year × water transportation ratio in base year + coal throughput in base year × water transportation ratio in base year × natural decline rate = coal throughput in target year × (water transportation in target year) Proportion - Water transport proportion in base year)

Among them, the coal traffic volume in the target year (2025, 2030) is calculated in combination with the total coal transportation volume in the base year of each port (2021) and the decreasing trend of coal consumption in the province in the future (The predicted results are shown in Table 3).

Table 3 Prediction result of coal MCRW in Zhejiang province

Port	Prediction result of coal MCRW (10,000 tons)	
	2025	2030
Ningbo Zhoushan Port	240	465
Jiaxing Port	227	330
Wenzhou Port	0	11
Total	467	806

4.2 Analysis of cement transport logistics

4.2.1 Analysis of the potential of MCRW of cement transport

Cement production enterprises are distributed in bands and highly clustered, and cement output is high in the north and low in the south. There are nearly 150 cement enterprises in Zhejiang province, mainly concentrated in Huzhou Changxing, Hangzhou Tonglu, Fuyang, Jiande, Jinhua Lanxi, Quzhou Jiangshan and Changshan and other places. Jiaxing, Ningbo, Quzhou, Jinhua, Huzhou, Hangzhou top six cement output in the province, except Hangzhou, Ningbo due to strong demand for infrastructure construction, local cement is still in short supply, the rest of the cities are the main cities of cement output. Zhoushan, Wenzhou, Taizhou, Lishui and other places have no clinker production, and there are only some grinding mills in the region, so the cement output is relatively low, and it is the main city of cement import.

The cement transportation in Zhejiang province is mainly to serve the local market, the waterway is the main mode of transportation in northern Zhejiang, and the road transport is mainly in western and central Zhejiang. In Zhejiang province, cement mainly flows to Quzhou, Huzhou, Jinhua and other northern and western Zhejiang areas, and to Wenzhou, Taizhou, Lishui and other southern and eastern Zhejiang areas. Road transport conventional transport distance of 50~200 kilometers, the longest up to 300 kilometers, the main cross-regional flow flow including Changxing into Jiaxing, Hangzhou north market; Tonglu, Fuyang, Zhuji and other places into Hangzhou, Shaoxing market; Jinhua, Quzhou into Taizhou, Wenzhou, Ningbo and other coastal markets, the rest for local, regional short distance road transport. Water transport is mainly sold in Huzhou, Jiaxing and other northern Zhejiang areas to southern Jiangsu, Shanghai and local, water transport accounts for about 70%-80%; Clinker mainly involves the purchase of clinker by sea in coastal grinding stations, Hangjiashao grinding stations and other places through the inland waterway purchase of clinker, some cement plants also need to pass the road short barge. Railway transportation is mainly for Changxing,

Jiangshan, Xuancheng and other places of enterprises sent to Ningbo, Wenzhou area of cement and a small amount of clinker.

Based on the current spatial distribution of cement and clinker production and sales in the province, combined with the characteristics of narrow cement transport radiation, small scale and short transport distance, the potential of MCRW is mainly based on the adjustment of the transport structure of large cement enterprises in the main cement supply places such as Quzhou, Jinhua and Hangzhou, and the increase of the proportion of cement clinker waterway transport at the port. In terms of cement enterprises, Southern Cement and Red Lion cement have gathered most of the production capacity in northwest Zhejiang, and are the key direction of MCRW. At present, the five large cement factories of Southern Cement have drafted the "14th Five-Year" logistics optimization and upgrading plan for Zhejiang Southern Cement according to the logistics conditions of each enterprise and its customers, planning to accelerate the construction of the enterprise terminal of Shanya South and Changshan South and the construction of the client's water transport transfer warehouse, give full play to the water transport conditions of Qiantang water system, and increase the MCRW Increase the sales volume of waterborne cement in Hangzhou city north, Xiaoshan, Shaoxing, Yuyao and other places. In terms of Hongshi cement, half of Tonglu Hongshi cement has been transported to Hangshao direction through the Fuchun River channel, and the future development potential is limited. In terms of port clinker transport, at present, there is still about 30 million tons of gap in our province to be transferred from outside the province, most of which come from Anhui, Liaoning and other provinces, and less of which are imported from Vietnam and other countries. Due to the small radiation range, the port is basically transported by road after receiving and unloading, and some clinker is temporarily transferred to small boat transport or transported to the hinterland through the transit station. With the opening of the waterway, the improvement of facilities and equipment and the development of sea-river combined transport business, there is a certain potential of MCRW.

4.2.2 Prediction of transfer volume from MCRW

From the perspective of cement production and consumption in the province, the existing market fluctuates and shows a trend of gradual saturation, and the natural growth of related transportation volume can be ignored. The direct downstream of cement is infrastructure and real estate, the current growth of the two has entered a flat period, accounting for the proportion of fixed asset investment is basically stable at about 60%, from the recent three years of cement production in our province (respectively 1.34 million, 132 million, 135 million tons), the cement production capacity in our province is basically 130 million in the middle and low fluctuations. Under the background that the country and our province continue to resolve the problem of overcapacity and strictly restrict new production capacity, it is expected that the cement production and consumption in the province will stabilize in the future and enter the structural optimization stage (the productivity layout will gather in the Changxing - Jiande - Qujiang - Changshan - Northwest Zhejiang area). Therefore, when estimating the potential of MCRW of cement, the impact of natural growth on the forecast results is temporarily ignored (The predicted results are shown in Table 4).

Table 4 Prediction result of cement MCRW in Zhejiang province

Core enterprises/ports	Prediction result of coal MCRW (10,000 tons)	
	2025	2030
Jiaxing Port	67	112
Wenzhou Port	100	200
Longyou Port	20	50
Changshan South cement	0	200
Shan Ya South cement	20	60
Lanxi Red Lion cement	20	30
Tonglu Red Lion Cement	20	30
Other cement enterprises	26	137
Toal	273	819

4.3 Analysis of grain transport logistics

4.3.1 Analysis of the potential of MCRW of grain transport

Grain logistics presents the characteristics of large-scale centralized inflow outside Zhejiang Province and small batch scattered transportation within Zhejiang province. In 2021, the total amount of grain imported and imported from outside Zhejiang Province is about 21.86 million tons. In recent years, the quantity and proportion of imported grain in Zhejiang Province have increased significantly, and the net purchase of grain from outside the province has increased slightly year by year. Among them, the transfer from outside the province is the main way to make up for the gap in grain production and demand in our province, which is generally transferred from Jiangsu, Anhui, Heilongjiang, Liaoning, Jilin, Shandong and other neighboring provinces and major grant-producing provinces, about 16.59 million tons, accounting for about 75.8%. Specifically, Jiangsu, Anhui, Jiangxi and other neighboring provinces bought a total of 8.26 million tons, accounting for 49.8%; The purchase volume of major grain-producing provinces such as the three Eastern provinces was 5.13 million tons, accounting for 30.9%; Shandong, Henan and other provinces bought 3.2 million tons, accounting for 19.3%. Foreign imports mainly come from Brazil, the United States, Ukraine, Argentina, Australia, Southeast Asia and other food-producing countries, about 5.27 million tons, accounting for 24.2%, an increase of 1.37 million tons over last year.

Grain transfer from outside the province is mainly by direct road, combined transport of public water and railway container. The transportation of grain imported from abroad is mainly water-water combined transport, supplemented by public water combined transport. The potential of "rotating water" is mainly to guide the inland transportation of grain in neighboring provinces, and to increase the proportion of grain shipping in distant regions. The

demand for grain imported from outside Zhejiang Province is strong, especially the purchase of Jiangsu, Anhui, Shanghai, Jiangxi and other neighboring provinces accounts for half of the imported grain imported from outside Zhejiang Province. At present, this part of grain transportation is still dominated by direct road transportation. Through unimpeded inter-provincial water transportation channels such as Zhejiang-Shanghai, Zhejiang-Jiangsu, Zhejiang-Jiangxi, Zhejiang-Anhui and other inland ports, the function of grain receiving and unloading operation can be improved. It has great potential to promote the transfer of grain transport from highway to waterway or public water transport. In addition, with the unimpeded Hangyong Canal and the upgrading and transformation of Zhoushan International Grain and Oil Industry Park, it will be conducive to the northeast, overseas and other distant areas to use water transportation through Ningbo Zhoushan Port to complete the distribution and transfer.

4.3.2 Prediction of transfer volume from MCRW

Based on the projected permanent population and per capita grain consumption of Zhejiang Province in the target years (2025 and 2030) and remaining unchanged (0.35 tons/(person year)), the total annual grain consumption of the province in the future is estimated, and the net grain purchase of the province is obtained by subtracting the annual grain consumption of the province from the annual grain production of the province (stable at about 6 million tons in the past four years). The volume of purchases from other provinces, the volume of imports from abroad and the volume of sales to other provinces are estimated by trend extrapolation according to the proportion data over the years. Since the grain data involves the safety of reserves and it is difficult to obtain detailed flow direction data, it is therefore set that the future sea-river combined grain transport target of Jiaxing Port, the proportion of MCRW in each target year and the waterway level of northern Zhejiang as a reference to complete 7% of the grain MCRW in 2025 and 11% of the grain MCRW in 2030 in the region with four-tier waterway conditions.

According to the estimates, by 2025, Zhejiang's grain purchase volume is expected to be 19.92 million tons, the export volume is expected to be 5.86 million tons, and the grain import volume is 6.43 million tons. Among them, a total of 9.92 million tons were purchased from neighboring provinces such as Jiangsu, Anhui and Jiangxi, and 6.16 million tons were purchased from major grain-producing provinces such as the three eastern provinces. By 2030, China will purchase 22.98 million tons of grain from other provinces, sell 6.76 million tons of grain from other provinces, and import 7.41 million tons of grain. Among them, the neighboring provinces bought 11.44 million tons, and the three eastern provinces bought 7.11 million tons. See Table 5 for details. In summary, the potential of grain MCRW in Zhejiang Province in 2025 is about 1.34 million tons, and the potential of MCRW in 2030 is about 2.43 million tons. The specific forecast results are shown in Table 6.

Table 5 Prediction results of grain consumption and purchase from 2025 to 2030 (unit: 10,000 tons)

Items	2021	2025	2030
Resident population	6540	7420	8300
Grain consumption	2314	2650	2964
Foreign purchase volume	1659	1992	2298
Neighboring provinces such as Jiangsu, Anhui and Jiangxi purchased quantity	826	992	1144
The purchase volume of the three eastern provinces	513	616	711
Overseas import	527	643	741
Sales outside the province	493	586	676

Table 6 Prediction result of grain MCRW in Zhejiang province (unit: 10,000 tons)

Potential direction	2025	2030
Shanghai, Jiangsu direction	49	89
Three eastern provinces, overseas direction	85	154
total	134	243

4.4 Analysis of container transport logistics

4.4.1 Analysis of the potential of MCRW of container transport

In terms of coastal areas, the container throughput of coastal ports in Zhejiang Province in 2021 is 34.89 million TEU, of which 31.08 million TEU is handled by Ningbo Zhoushan Port, accounting for 89%. From the perspective of collection and distribution structure, the proportion of containers transported by road, rail and water is 70:4:26, and most of them are completed by road transportation, only 8.2 million TEU are passed by water, and the collection and distribution structure has not been substantially improved compared with 2020 (70:3:27) and 2017 (41:1:58). In terms of inland waterways, more than 30 inland container routes have been developed in Zhejiang province, and the container throughput of inland ports in the province reached 1.22 million TEU in 2021, more than doubling in the past five years (600,000 TEU in 2017), with an average annual growth rate of 19.4%. In terms of sea-river combined transport, Jiaxing, as the main source of inland container transport in Zhejiang province, has strengthened policy support and financial subsidies for container sea-river combined transport in recent years. At present, there are 19 inland ports and 21 routes docking with Jiaxing Port, covering northern Zhejiang, central Zhejiang and western Zhejiang, and expanding to southern Jiangsu, central Anhui and other places, and the cargo source hinterland is constantly deepening inward.

The potential of container MCRW is mainly in northern Zhejiang, supplemented by eastern Zhejiang, western Zhejiang and southern Zhejiang. The container development foundation in northern Zhejiang is the best. According to the survey, it is expected that by 2025, the container sea-river combined transport throughput target will exceed 1.6 million TEU. In eastern Zhejiang, with the renovation

of the Hangyong Canal, the construction of a number of wharf operation areas such as Shaoxing, Zhuji, Xiaoshan and Shangyu, and the exploration and expansion of business from Ningbo to Hangshao and Jinhua in western Zhejiang, the potential of inland container MCRW is expected to be further explored. In western Zhejiang Province, relying on the improvement of the three-level waterway in the middle and upper reaches of Qiantang River and the construction of Qujiang, Longyou, Fangxiadian, Nwbu and other wharf operation areas, some containers from Jinhua, Quzhou to Hangzhou, Ningbo and other places are expected to abandon land and water. However, due to the mature development of railway container logistics on this line and better timeliness, the volume of MCRW in this area is not large. South Zhejiang Province relies on the Oujiang River channel to open up the southwest Zhejiang region directly to the sea, with the further development of Wenzhou to Ningbo Zhoushan branch line, some goods can be through the MCRW through the Oujiang River container river-sea combined transport.

4.4.2 Prediction of transfer volume from MCRW

Jiaxing Port, Ningbo Zhoushan Port, Quzhou Port and Wenzhou Port, the core ports of northern, eastern, western and southern Zhejiang channels, were focused on to predict the potential of container MCRW in the direction of major channels. Due to the lack of specific container throughput collection and distribution structure data, we refer to the container sea-river combined transport and river-river transfer business increment of ports, exclude the natural growth rate of container water transport (take cargo throughput growth rate), and comprehensively predict the MCRW potential of the container in Zhejiang province in the target years (2025, 2030).

Among them, the growth trend of container water transport business volume such as sea-river combined transport and river-river transfer in the northern and eastern Zhejiang channels is extruded to the target year, and the natural growth of container water transport business volume is subtracted on this basis to obtain the container MCRW potential of each channel in the target year. The size of the inland container business in the southern and western Zhejiang channels is small, so all the incremental container business in the future target year can be included in the MCRW potential (assuming that all the business growth is water transport business). The prediction results are shown in Table 7

Table 7 Prediction result of container MCRW in Zhejiang province (unit: 10,000 TEU)

Channel direction	2025	2030
Northern Zhejiang passage	100	174
Eastern Zhejiang passage	0.1	0.2
West Zhejiang passage	5	13
Southern Zhejiang passage	15	25
Total	120.1	212.2

5. Conclusion

The analysis results of MCRW potential of coal, cement, grain and container transportation logistics are sorted out, and the container volume is converted to 8 tons per TEU (the average container weight of Zhejiang province is about 10 tons, the empty container weight is about 2 tons, equivalent to about 8 tons of cargo), and the MCRW potential of the four major cargo types in the province is summarized in the table 8.

It can be seen that by 2025, containers have the greatest potential to contribute to the development of MCRW in Zhejiang Province, followed by coal, cement and grain; By 2030, with the significant improvement of waterway and terminal conditions in western Zhejiang, cement water transport business will be further expanded, although container is still the largest cargo type of "revolution water" contribution potential in the province, but the contribution potential of cement is more than coal, ranking second.

Table 8 The potential of MCRW in four major goods in Zhejiang Province (unit: 10,000 ton)

Cargo name	2025	2030
coal	467	806
cement	273	819
grain	134	243
container	120.1/961	212.2/1698
total	1835	3566

The MCRW potential of each channel is sorted out, and the MCRW potential of the four major water transport channels in Zhejiang Province is summarized in table 9.

Table 9 Potential of MCRW in four major channels in Zhejiang Province (unit: 10,000 tons)

Channel direction	2025	2030
Eastern Zhejiang passage	326	621
Northern Zhejiang passage	1143	1923
Southern Zhejiang passage	220	411
West Zhejiang passage	146	611
Total	1835	3566

It can be seen that by 2025, the development potential of MCRW in the northern Zhejiang Channel is the greatest, and it should be regarded as a key area of attention; The east Zhejiang Passage has great potential of coal MCRW. The potential of MCRW in south Zhejiang passage is mainly cement; The West Zhejiang Channel is still in the stage of construction and development by 2025, and the potential of the relevant cargo MCRW has not been fully stimulated.

By 2030, the scale of container and coal MCRW in northern Zhejiang Channel is expected to continue to expand, further consolidating the first position of MCRW potential in Zhejiang Province; The development of coal and grain MCRW in the eastern Zhejiang Passage continued to advance; The MCRW of the mine construction and cement in the west Zhejiang Passage is obvious, the MCRW of the container is further promoted, and the comprehensive potential scale continues to narrow with that of the East Zhejiang Passage; Due to the limited demand for coal and grain in the inland hinterland of the southern

Zhejiang Channel, it is difficult to effectively promote the MCRW of related cargo transportation logistics, and the increment of container MCRW is small, and the comprehensive potential is small.

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Disclosure statement

No potential competing interest was reported by the authors.

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