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Assessment of energy saving and emission reduction for Yangshan deep water port container water-water

Song Hua Wei [1, a], Fan Bao Rong [2, b]

[1]School of Shanghai Maritime University, Shanghai 201306, China;

[2]School of Shanghai Maritime University, Shanghai 201306, China.

[a]13119409230@163.com, [b]949471320@qq.com

Abstract

Container water-water transfer is of great significance for energy conservation and emission reduction and the promotion of the construction of the Shanghai International Shipping Center. In order to objectively evaluate the energy saving and emission reduction effect of water-water transfer, taking into account the waterway transportation , port loading and unloading time, through the activity-based method, the foreign trade container transportation from TaiCang City to Yangshan Deepwater Port Area was taken as an example to establish a container energy consumption and emissions models for transporting water-water. According to the calculation, if the TaiCang foreign trade container road transport part is changed to the water-water transfer mode, the energy saving amount is 8140.3tec, emission reduction amounts are 30,100 t, 121.8 t, and 3.91 t, respectively. The huge energy-saving emission reduction not only responds to the call of the state, but also reduces the transportation cost, helps the relevant personnel to understand the energy-saving and emission reduction effects of the route, and provides reference for the formulation of the water-to-water transfer promotion policy.

Keywords

Waterway transportation ; Energy conservation and emission reduction ; Activity-based method ; Water-water transfer ; Yangshan deep-water Port

1. Introduction

Container "water-water transfer" refers to the mode of transportation of containers by waterway, from the port of departure to the port of destination through transshipment and then transported to the port of destination. As a modern way of collecting and distributing, “water-water transfer” can effectively realize the economics of logistics and help solve urban traffic congestion and environmental pollution caused by road transportation. "Water-water transfer" has the advantages of low energy consumption, less pollution, long transportation distance and large transportation volume, and is the lowest cost among various transportation modes. Take the container transportation of the Yangtze River as an example: According to estimates, from Chongqing to Shanghai, the three transportation modes of Yangtze River shipping, railway and highway are selected. The unit freight rate is about 1:2:6; the transportation turnover per kiloton of highway, railway and Yangtze River trunk line energy consumption ratio is 14:2:1; the unit discharge of pollutants for waterway is 1/15 of the highway and 5/6 of the railway. At the same time, the noise pollution of waterway is relatively small, and the noise generated by ships with unit freight turnover is only equivalent to 4.7% of trucks[1]. “Water-water transfer” has the potential to be sustainable. It provides green transportation services, complies with national policies, and can generate huge environmental and economic benefits. It has a great role in

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promoting the industrial layout and structural adjustment of waterway and promoting the coordinated development of the comprehensive transportation system.

In August 2016, Shanghai announced the draft of Shanghai Urban Master Plan (2016-2040). According to the plan, the container throughput of Shanghai Port will remain at around 45 million TEU by 2040. It is necessary to optimize and improve the port function and layout. The function of the port hub was upgraded. The Yangshan Deepwater Port Area and Waigaoqiao Port Area were the core, and the Hangzhou Bay and Chongming Island were complemented. It will highlight the joint operation of rivers and seas, speed up the construction and development of high-grade waterways and supporting port areas, vigorously develop “water-water transfer”, and increase the proportion of international container transfer. By 2040, the proportion of water-water will reach over 60%. Vigorously developing container "water-water transfer" transportation is an important way for the world ports to compete for the status of an international shipping center, and is also an important symbol of the international status of a port.

The 2009 Copenhagen Climate Conference pointed out that China's carbon emissions have accounted for 20% of global carbon emissions, making it the world's largest carbon emitter. In the "Shanghai City Master Plan", it proposes to actively respond to global climate change and enhance the ability of cities to resist natural disasters. The transportation industry is a key area for national energy conservation and emission reduction and climate change, and water operation is an important part of transportation. Energy conservation and emission reduction have great advantages, and attention to its emission reduction problem has become a very important and practical scientific issue.

2. Problem description and modeling

2.1 Development of container water transfer in Yangshan Deepwater Port

In 2018, Shanghai Port (harbour) has 1,121 various types of berths, of which 223 are berths above 10,000 tons, the terminal is extended to 106.1 kilometers, the cargo handling capacity is 526 million tons, and the maximum berthing capacity is 300,000 tons. The length of the dock shoreline is 17,980 meters, the berth is 54, the yard area is 7,486,500 square meters, the bridge is 152, the tires are 397, the stacker is 93, and the truck is 134. Figure 1 shows an overview of the infrastructure of Shanghai Port in 2018.

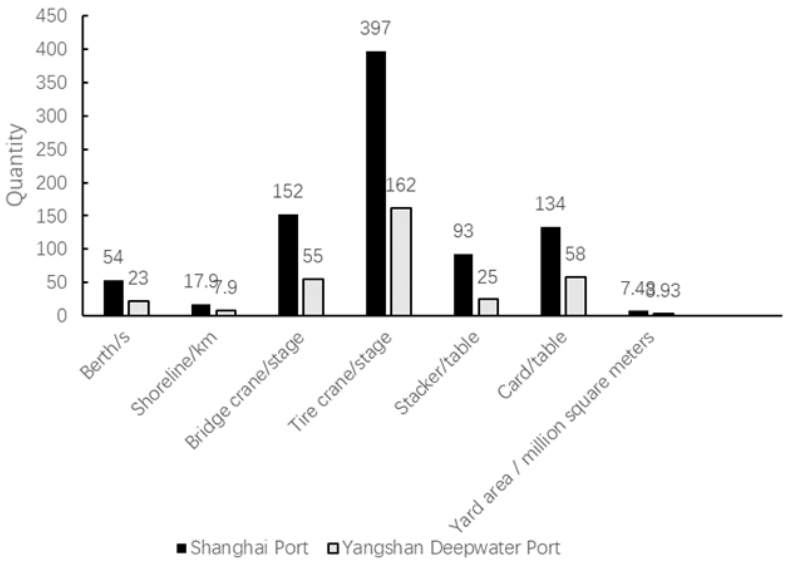

Figure 1 Infrastructure of Shanghai port in 2018

In 2018, Shanghai Port completed a container throughput of 42.01 million TEUs, a growth rate of 4.4%, and container throughput reached a record high. Yangshan deep-water port throughput was 18.425 million TEU, with a growth rate of 11.30%, the highest in the past five years. The international transfer box has remained basically unchanged, and the water-water transfer ratio has also increased

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to 47.0%. Figure 2 is a schematic diagram of container throughput, international transfer capacity and water-to-water ratio for Shanghai Port and Yangshan Deepwater Port in 2012-2018.

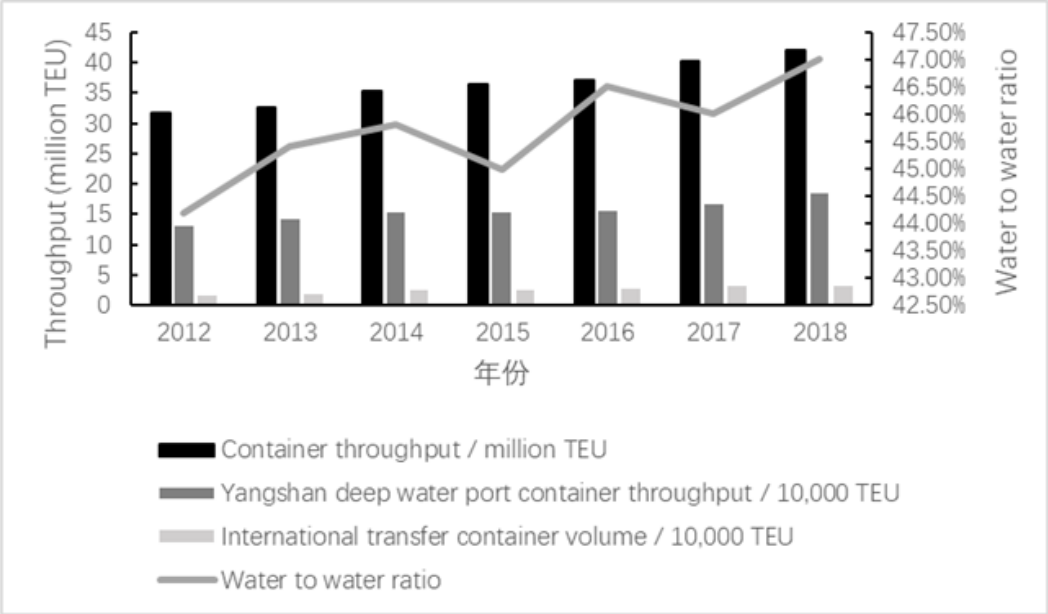

Fig.2 Shanghai Port's recent throughput and other major data

The Yangshan Deepwater Port Area is located on the Qiqu islands of Zhejiang Province. There are three types of container collection and distribution methods in the Yangshan Deepwater Port Area, including direct road transport through the Donghai Bridge and rail transport through the Luchaogang Container Transfer Station. Waterway transportation is carried out along the inland river (coastal) branch line[2]. The Yangshan deep-water port road collection and transportation mode is connected to the A2 Hulu Expressway and the mainland through the Donghai Bridge. The Donghai Bridge design has an annual capacity of 5 million TEUs. As early as 2012, the Donghai Bridge reached saturation level due to excessive dependence on the road. Transportation has triggered a series of congestion problems, environmental pollution problems and safety issues. The railway collection and distribution system is the weakest link in the Yangshan deep-water port area. Although the container sea-rail combined transport volume increased to 79,000 TEU in 2018, it only accounts for 0.42% of the Yangshan deep-water port throughput. It must be transported by sea-rail combined transport. The container must be transported to the Luchaogang Station for reloading and transportation through the card, and the Donghai Bridge cannot be bypassed. As a result, the road traffic congestion problem cannot be alleviated in a short time.

2.2 Water transfer mode of Yangshan Deepwater Port

International container water transfer can evaluate the competitiveness of hub ports, and is an important indicator for measuring international shipping centers. It can also evaluate the competitiveness of hub ports. The international transfer process is generally after the foreign one-way ship calls the Yangshan deep-water port area, and the container that needs to be unloaded in the Yangshan deep-water port area is completed, and then the next ship of the container is shipped and leaves the Yangshan deep-water port area to leave the country; Or after the ship has completed the unloading work, the container that has been unloaded by the shuttle bus or the truck will be transported to the Waigaoqiao Wharf, and the next ship will be driven out of the Waigaoqiao Wharf to complete the water transfer of the international container. As shown in Figure 3.

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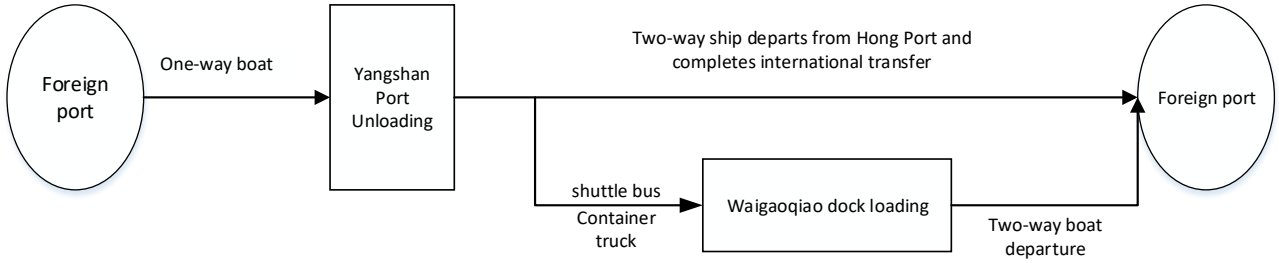

Fig.3 Yangshan deep water port international water transfer mode

The Yangtze River inner branch/coastal transfer takes up most of the water. The main process of the Yangtze River inner branch is: the upper and middle reaches of the Yangtze River containers to transfer to the Yangshan deep-water port area in Taicang Port, or arrive by rail or rail. Yangshan deep-water port area, after which it was loaded with international cargo ships. The coastal transit is similar to the Yangtze River internal branch line, except that the shuttle bus is changed to an offshore freighter. The import is opposite to the export direction, as shown in Figure 4.

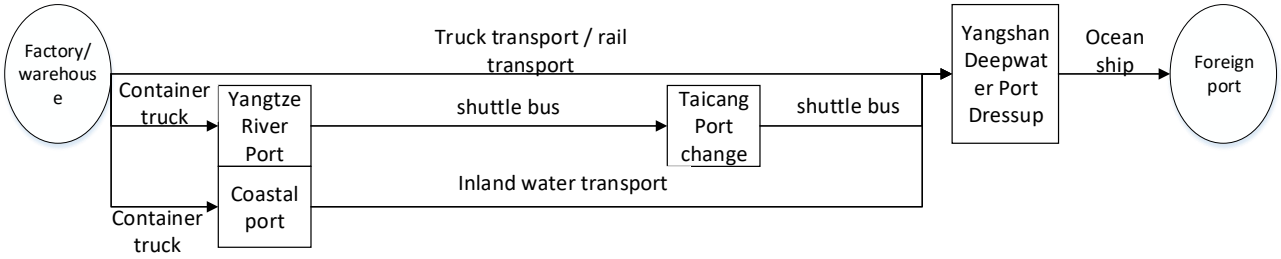

Fig.4 water transfer pattern in the distributions of the Yangtze River and coastal port

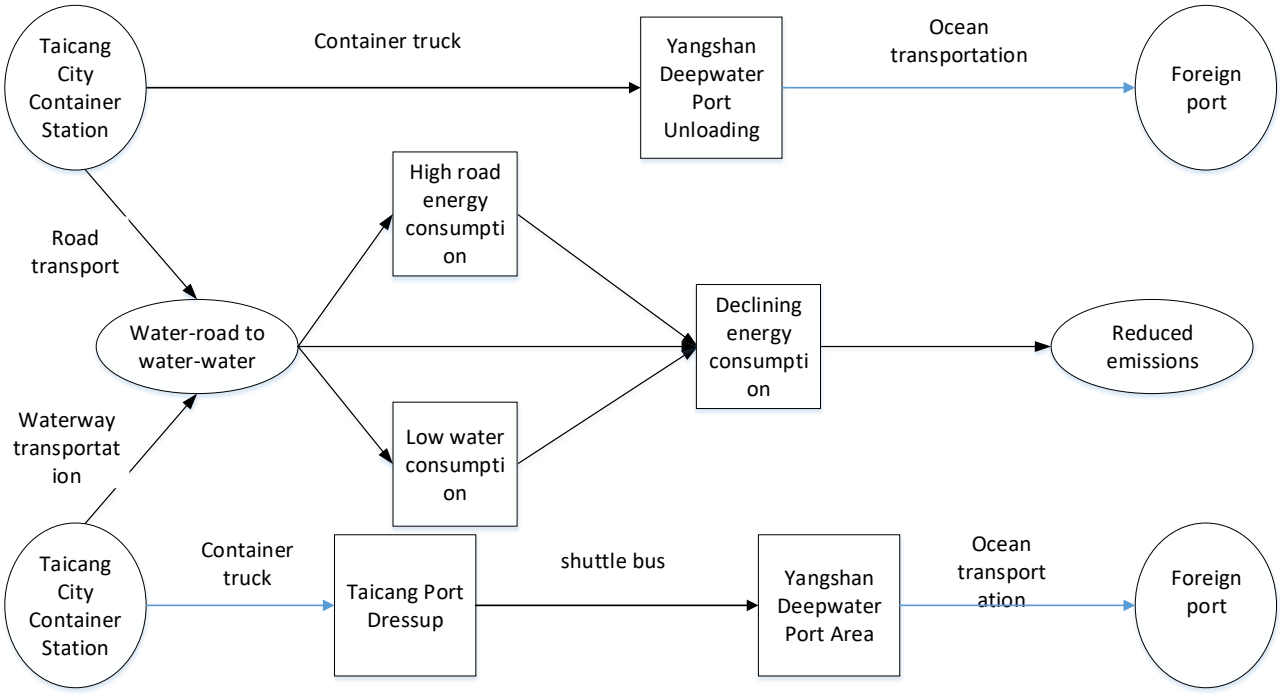

Fig.5 schematic diagram of energy saving and emission reduction in water-water transfer

Taking the foreign trade container transportation of Taicang City as an example, the principle of energy saving and emission reduction in water-water is analyzed. Road transportation consumes more energy, emits more pollutants, and the waterway consumes less energy and emits less pollutants. Therefore, the foreign trade container can be significantly reduced in energy consumption and emissions after being converted from sea-maritime transport to water, thus achieving energy saving. Further analysis shows that the contribution of energy saving and emission reduction in container water is mainly determined by the difference between the energy intensity of the road waterway and

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the pollution of the part of the container that is run by the sea-federation, and the difference in emission pollution[3], and The transportation of international freighters in the latter half has nothing to do with.

According to the above analysis, the energy saving (emission reduction) of the water in the Yangshan deep-water port area is equivalent to the road energy consumption (emission) minus the waterway energy consumption (emission) under the same traffic volume. Due to the lack of detailed energy consumption statistics of the system, this paper uses the fuel consumption method to estimate the energy saving and emission reduction of container water. According to the calculation method provided in the IPCC National Gas Inventory Guide, the specific formula is as follows:

$$E_{truck1}^{i} = P_{truck} \times t_{truck}^{i} = \frac{Q \times FC_1 \times L_1}{200} \times t_{truck}^{i} \tag{1}$$

In formula (1), the fuel consumed for the truck transport container, the transport volume of the container, the distance traveled for the whole road, is the fuel consumption of the 100 km of the card, when the value is 1, 2, 3, 4 and Represents the amount of standard coal consumed by the card, the standard coal coefficient of diesel, the amount of emissions, the emission factor, the emission factor, the emission factor, and the emission factor.

$$E_{\mathrm{ship}}^{\mathrm{i}} = E_{\mathrm{ship1}}^{\mathrm{i}} + E_{\mathrm{truck2}}^{\mathrm{i}} \tag{2}$$

$$E_{\mathrm{ship1}}^{\mathrm{i}} = \sum\sum P_{\mathrm{jk}} \times \mathrm{t}_{\mathrm{k}}^{\mathrm{i}} \tag{3}$$

$$P_{\mathrm{jk}} = T_{\mathrm{j}} \times FC_{\mathrm{k}} \tag{4}$$

In the formula (2)(3)(4), when i=1, E_{ship}^{1} , E_{ship1}^{1}, E_{truck2}^{1} respectively, the energy consumption in the whole process of water and water, the energy consumption of the waterway in the water, and the transportation from the destination port terminal to the warehouse. Yes, when the upper standard value is 2, 3, 4, respectively, the discharge coefficient of the corresponding emission amount, the emission factor. =1 indicates heavy oil, and k=2 indicates light oil, which indicates the emission coefficient of heavy oil and light oil, and the emission coefficient of PM, and the emission coefficient of PM. When j=1, the state of the ship is taken as the voyage, and when j=2, the state of the ship is taken in the state of the port, and the consumption of the oil in the j state of the ship indicates the time of the ship and the time of arrival in the port. It represents the fuel consumption rate of heavy oil and light oil for ships, and represents the standard coal coefficient of heavy oil and light oil.

$$\Delta E^{\mathrm{i}} = E_{\mathrm{truck1}}^{\mathrm{i}} - E_{\mathrm{ship}}^{\mathrm{i}} \tag{5}$$

In the formula (5), when i=1, 2, 3, 4, it represents the energy saving amount, the emission reduction amount, the emission reduction amount, and the PM emission reduction amount.

3. Case study on energy saving and emission reduction effect of water and water transfer

In the 1990s, with the reform and opening up, the economy in Suzhou was booming, mainly in the secondary and tertiary industries. The open economy brought a lot of trade, and the cargo turnover increased year after year. Located in the mouth of the Yangtze River, Taicang Port is adjacent to the Shanghai Economic Center. It is also at the forefront of Jiangsu Province's opening to the outside world. It has a coastline of 38.8 kilometers and a depth of 12.5 meters of the Yangtze River, and is a river port full of port management. It is the best node for river-sea combined transport and a reliable port for sea-going into the river. The sea and land transport are very developed.

At 0:00 on July 21, 2014, the water shuttle bus from Jiangsu Taicang Port to Shanghai Yangshan Port was launched. The foreign trade containers in the upper reaches of the Yangtze River, such as

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Chongqing, Wuhan, Changsha and Jiujiang, which were transported by the 34 branch shipping companies of the Yangtze River, were all transferred to Taicang Port. This will enable Taicang Port to increase throughput by 600,000 TEU per year. The greater advantage of transshipment goods in Taicang Port is to reduce costs. Taking the export of ocean container in Suzhou city as an example, the transfer to Yangshan Port in Taicang Port can save at least 200 yuan to 600 yuan compared to the transportation of containers by land to Yangshan Port[5]. The successful navigation of the water bus is an important step for the Yangtze River strategy for Shanghai Port. It is a big step for Taicang Port to integrate into the Shanghai International Shipping Center.

Containers produced in Taicang City can be divided into domestic trade containers and foreign trade containers. All foreign trade containers are transported to Yangshan Deepwater Port Area. Due to the lack of detailed data, they can only be based on the total volume of foreign trade imports and exports. The city's 2018 foreign trade box production volume was 590,000 TEU[6]. Assume that the container produced in Taicang City is transported to the Yangshan Deepwater Port from the industrial road container station as shown in Figure 6.

Fig.6 container transportation route from Taicang City to Yangshan deep water port area

Route 1 starts from G15, G1501 expressway, and S crosses the Donghai Bridge to reach the destination. The whole journey is 184 kilometers, which takes 8.5 hours. Route 2 is transported from the starting point to Taicang Port 20 km away, and then from Taicang Port to the Yangshan Deepwater Port Area by waterway. The distance is 90 nautical miles and the whole time is 16 hours.

Because the goods are sensitive to different factors such as time freight rate, the owner can choose the route differently. The Logit model of the container road transportation sharing rate of Taicang City can be established to calculate the proportion of land and water transportation. The Logit model is used to predict the transportation channel. A more mature method of sharing the various modes of transportation, assuming that the choice of each shipment of the owner is independent, but as the utility function of the transportation mode increases, the results increase exponentially, according to Chen Feng[7] For the improvement of the model, the following formula can be obtained:

$$P_x = \frac{\exp(U_x/\overline{U})}{\sum_{x=1}^{n}\exp(U_x/\overline{U})} \tag{6}$$

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Among them, P_x is the sharing rate of the x transportation mode , U_x is the generalized cost value of the x transportation mode, and $\overline{U}$ is the average generalized cost of various modes of transportation. The generalized cost is the sum of the product of the base freight rate and the transit time and the time value of the goods. According to Zhao Yiran[8] on the time value of container transportation in Central Europe, the average value of the time value of various container cargoes is 48.9 yuan / (TEU·h), through the tariffs given to many Taicang container shipping companies. And the average transportation time can be obtained: the freight rate of container road transportation is 1238 yuan, and the freight rate of container waterway transportation is 967 yuan.

According to the China Port Yearbook, the Yangtze River direct ship type research [9], Dalian port ship emissions inventory research[10], "port energy consumption statistics and analysis methods", "road motor vehicle air pollutant emission inventory preparation technical guide (trial) The following data and Table 1 data were obtained in the literature: the shuttle bus was loaded with 252 TEU, the speed was 12 kn, the average loading rate was 85%, the loading speed of the Yangshan deep-water port was 48 TEU/h, and the loading speed of Taicang Port was 35 TEU/h.

Table 1 parameters table of energy-saving and emission reduction for Yangshan deep-water Port's Container water-water transfer

parameter	numerical value	parameter	numerical value
FC_1	35L/100km	t_{truck}^1	1.253kgce/L
t_{truck}^2	3.758kg/TEU·km	t_{truck}^3	18.209g/TEU·km
t_{truck}^4	0.558g /TEU·km	FC_1	7.2t/d
FC_2	0.75t/d	t_1^1	1.20t/t
t_2^1	1.25t/t	t_1^2	803.10kg/t
t_2^2	710.52kg/t	t_1^3	17.50kg/t
t_2^3	17.25kg/t	t_1^4	0.67kg/t
t_2^4	0.33kg/t		

In the calculation process, since there is no difference in the second half of the transportation, it is not within the calculation range. The container road transportation and water are transferred to the Yangshan deep-water port area, and the loading and unloading links do not consider the energy consumption and discharge of the loading and unloading equipment. Consider transportation equipment. Both heavy and light oils can be used during ship navigation, and only light oil is used when loading and unloading. Through calculation, the share of road container transportation is 48.6%, the energy consumption of road and waterway is 11.6 million tec and 3459.7tec, respectively, and the CO_2 emissions are 34,700 tons and 4,563.13 tons, respectively, and the NO_x emissions are 168.12t and 46.32t respectively. The PM emissions are 5.15t and 1.24t respectively. Compared with the truck transportation, the water saving is 8140.3tec, and the CO_2, NO_x, PM emission reductions are 30,100t, 121.8t and 3.91t respectively.

4. Conclusion

This article briefly introduces the Yangshan deep-water port area collection and distribution system, as well as the transportation mode of Taicang Port's foreign trade container water. According to the foreign trade container transportation of Taicang City, a model for quantitative calculation of energy saving and emission reduction was established. The fuel consumption method was used to evaluate the benefits of energy saving and emission reduction from Taicang City to Yangshan Deepwater Port

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Area. The study found that the way of transporting containers in water and water has a significant effect on energy conservation and emission reduction. With the gradual outward shift of Shanghai International Airport, the integration of Shanghai-Taiwan customs clearance, and the integration of more ports with Shanghai Port, the containeres that need to be transported to Yangshan Terminal in the upper reaches of the Yangtze River are rising, and the water and water are transported. The demand has also increased. However, at present, the water and water transfer facilities of Yangshan Port are not perfect enough to meet the growing demand. The construction of water transfer docks can enable shuttle buses and other transit vessels to achieve a single point of berthing at dedicated terminals, reducing the normal production of the port area. The impact of the guarantee of timely berthing and fashion unloading of the feeder vessels, effectively guarantee the schedule and improve the efficiency of the production operations of the terminal. Due to the different characteristics of the inland rivers and sea areas, according to the requirements of the ship's specifications, the current inland river vessels cannot directly enter the sea area, and must be transported by reshipment of sea vessels. Relevant agencies should speed up the study of rivers and seas to enhance the direct transportation mode of rivers and seas. Reduce the traffic pressure on the cross-sea bridge. Shanghai's inland waterway has a low level, and there are many obstacle-constrained buildings. The port facilities along the river are poor. The inland river container ships are not standardized, and there are certain restrictions on the water and water transfer. In the future, we should focus on opening up the direct transportation of rivers and seas, speeding up the construction of rivers and direct waterways, planning the port area, and improving the shipping network near the Yangshan deep-water port area, so that the water and water transfer will occupy a larger part in the Yangshan deep-water port area collection and distribution system. proportion.

Acknowledgements

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