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Promote Port Shore Power Development Green Port

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Abstract

With the rapid growth of China's economy in recent years, the shipping trade between China and foreign countries has expanded on a large scale, and more and more ships have visited our ports. Especially in recent years, with the development of shipbuilding technology and the needs of shipping, the number of large tonnage ships has grown rapidly. The burning of fuel oil by ships during port calls will bring a lot of gas pollution and serious noise pollution. The use of shore power to replace generators can effectively reduce the environmental pollution caused by burning fuel oil. In order to protect the port environment, promote energy saving and emission reduction of the port, improve the port's comprehensive competitiveness, build a "green port", and promote the development of the port's shore power system, this article describes the necessity, application status and types of the port's shore power system development. The economic and social benefits of the shore power system are summarized and analyzed in combination with domestic and foreign studies, and related suggestions are given for the issue of port shore power.

Keywords

Environmental Protection; Port Shore Power; Application Status; Problem Suggestions.

1. Introduction

For a long time, ports have been the main and key nodes of global trade and are vital to the economy of all parts of the world (QuandMeng, 2012). With the implementation of my country's "One Belt, One Road" strategy, port construction has been further accelerated. At the same time, the number of ships at the port has continued to increase and fuel consumption has also increased. However, the use of fuel produces a lot of pollutants, which brings serious environmental pollution problems around the port. According to the research report of the Yangtze River Navigation Administration Bureau of the Ministry of Transport: At present, the fuel consumption of marine diesel engine power generation is generally 220 grams to 250 grams per kilowatt hour. According to statistics from the Yangtze River Navigation Administration Bureau of the Ministry of Transport, the specific emissions of one cubic meter of diesel combustion are shown in Table 1. According to statistics, the carbon emissions generated by the auxiliary generators of ships during the berthing period account for 40% to 70% of the total carbon emissions of the port. It is an important factor affecting the air quality of the port, the city where it is located, and the surrounding area factor.

When the ship berths in the port, the port shore power system is used to replace the auxiliary engine fuel-fired power generation with shore power to meet the power demand of the ship. The shore power reduces the pollutant emissions of the ship by more than 99% when it is berthing.

Table 1. Fuel emission pollution

Fuel consumption/m3	carbon dioxide/kg	nitrogen dioxide/kg	sulfur dioxide/kg	Smoke dust/kg
1.0	2616.6	8.6	10.0	1.8

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2. Port shore power technology principle

The principle of the port shore power technology is that the ship's engine is stopped by the ship at the port, and the shore power of the terminal (in the port area) supplies power to the ship's facilities and equipment to reduce pollution emissions when the ship is berthed in the port. The port shore power system is mainly composed of three parts: shore-based power supply system, ship-to-shore connection system and ship-borne power receiving system. The shore-based power supply system is powered by the front-end substation of the port (terminal). After voltage transformation and frequency conversion, the input power supply is converted into power that meets the needs of the ship. The power is delivered to the shore-based socket box and other facilities and equipment by using cable trenches and transmission trestle bridges. Finally, power is supplied to the ship after voltage transformation through the shipboard transformer. Shore power technology is an emerging comprehensive system solution project. In the specific use process, different methods of ship power supply should be provided for different actual conditions.

3. The necessity of developing port shore power

3.1 National Policy

The report of the Nineteenth National Congress of the Communist Party of China listed the "Pollution Prevention and Control War" as one of the three key battles for building a well-off society in an all-round way. Ship emissions are one of the areas to prevent and control air pollution. The use of shore power when ships are in port can effectively reduce sulfur oxides, Nitrogen oxides, particulate matter and other atmospheric pollutants, reducing noise pollution is the most effective way to reduce emissions. In recent years, my country's Ministry of Transport has vigorously promoted the use of shore power for ships calling at ports, and has successively issued the "Port Shore Power Layout Plan", revised the "Port Engineering Construction Management Regulations" and the statutory ship inspection technical rules, and worked with the Ministry of Finance and the Development and Reform Commission. The Ministry of Finance and the Ministry of Finance issued a financial incentive policy, established and improved a standard system, unified the technical requirements of ports, ships, and electricity, and issued the "Notice on Further Promoting the Use of Shore Power by Ships in Ports". The requirements for the use of shore power are specified in the implementation plan of the air pollutant emission control zone. In order to accelerate the construction of a powerful transportation country, implement the requirements of the Air Pollution Prevention and Control Law, strengthen the prevention and control of air pollution during ships' berths, formulate and promulgate regulations and rules for the management of port and ship shore power, and provide support for the construction and use of shore power (power receiving) facilities, services and safety It is very necessary and urgently needed to carry out comprehensive and systematic regulation and guidance.

3.2 Pollution in my country's ports

3.2.1 General situation of ships in Chinese ports

In 2018, the national port cargo throughput reached 14.351 billion tons, ranking first in the world. Among the top ten ports in the world in terms of port cargo throughput, China accounted for 7 (Ningbo Zhoushan first and Shanghai second), with 137 million water-carrying vessels; in the same year, the national ports completed a container throughput of 251 million TEU, compared with the previous year. An increase of 5.3%. By the end of 2018, there were 23,919 berths for port production in the country, with berths of 10,000 tons and above, as shown in Table 2 below. Among them, there are 1297 specialized berths.

3.2.2 Port ships have become an important source of pollution in port cities.

According to the calculations of the Natural Resources Conservation Association, assuming that a medium to large container ship uses marine fuel oil with a sulfur content of 35000ppm (3.5%) and drives at 70% of the maximum power, the total PM2.5 emitted per day The maximum amount is equivalent to the emission of 500,000 National IV trucks in my country in one day (The data comes

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from the "White Paper on Air Pollution Prevention and Control of Ships and Ports in China" by the Natural Resources Protection Association); according to estimates, the PM2.5 emitted by a medium and large container ship when it is in the port is equivalent to the total emissions of 4,000 trucks.

Table 2. Number of berths of 10,000 tons and above in national ports (unit of measurement: units)

Berth tonnage	National ports	Increase from last year	Coastal port	Increase from last year	River port	Increase from last year
Total	2444	78	2007	59	437	19
10,000 to 30,000 tons (not including 30,000)	845	11	656	5	189	6
30,000 to 50,000 tons (excluding 50,000)	416	17	294	9	122	8
50,000 to 100,000 tons (excluding 100,000)	786	24	672	19	114	5
100,000 tons and above	397	26	385	26	12	

Data source: Ministry of Transport

3.2.3 The most important pollutant in the port and shipping industry—fuel combustion

The exhaust gas of marine diesel engines contains a lot of pollutants such as sulfur oxides (SOx), nitrogen oxides (NQx), hydrocarbons (CH), and particulate matter (PM), and the pollutants are more harmful to the human body. As shown in Table 3 below.

Table 3. The degree of harm of different pollutants to the human body

Name	Shadow whistle on the human body
Sulfur dioxide	reduces visual range, tears, and inflammation of the eyes. Smell peculiar smell, chest tightness, inflammation of the respiratory tract, difficulty breathing, pulmonary edema, rapid ventricular death
Hydrogen sulfide	foul smell, nausea, vomiting, affecting human breathing, blood circulation, endocrine, digestion and nervous system, coma, poisoning and death
Hydroxide smell	bronchitis, trachea, pulmonary edema, emphysema, difficulty breathing, until death
Dust	damage the eyes, reduce the scope of vision, cause chronic bronchitis, infant asthma and sitting lungs, increase mortality, can be reduced, and increase traffic accidents
Photochemical smog	clear eyes, redness and swelling, reduced vision, headache, chest pain, body pain, paralysis, pulmonary edema and severe death within 1 hour
Hydrocarbons	skin and liver damage, causing cancer and death
Carbon monoxide	dizziness, headache, anemia, severe myocardial damage, central nervous system paralysis, difficulty breathing, severe death within 1 hour

3.3 Historical lessons

In the early 1970s, water transportation used to be the bottleneck of my country's opening up and economic development. Due to the insufficient and backward port facilities at that time, a large number of ships queued up outside the port, causing my country to suffer huge economic losses. It has a bad influence on our country's international reputation. But compared to Japan, Japan is an island country with poor resources and its economy entered the early stage of its heyday. It was the first to develop the water transportation industry. It invested a lot of money in port construction and formulated a lot of support policies. As a result, high-quality products manufactured through ship and port transportation enter the world market, making it one of the developed countries in the world in a short time. This painful historical experience and lessons made us deeply aware of the important position of water transportation and port construction.

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4. Current status of port shore power system usage at home and abroad

4.1 Domestic status

On March 22, 2010, Shanghai Port conducted an attempt to build a shore power system at the Waigaoqiao Phase II Container Terminal, which was mainly for container ships and the scale of the project was small. In October of the same year, Lianyungang Port tried to input 6.6kV/60Hz shore power for the "Star of China and South Korea", which became the first case of high-voltage shore power supplied by a Chinese port.

As of the end of 2019, the five types of berths in the "Port Shore Power Layout Plan" covered a total of 787 berths (including 525 coastal port berths), which is 160% of the minimum construction target (493 berths). Compared with (616), an increase of 171, including an increase of 124 coastal berths and an increase of 47 inland berths, the current coverage rate of port shore power facilities in my country has exceeded 71%.

In early January 2019, the 20000TEU super-large container ship "COSCO SHIPPING Sagittarius" under the COSCO SHIPPING Group successfully received shore power at the Shanghai Guandong International Container Terminal. This is also the world's first shore power connection for a 20000TEU super-large container ship. The success indicates that my country's Guandong Wharf's high-voltage variable frequency shore power boarding-related technology and engineering support capabilities have reached the world's advanced level.

4.2 Current situation abroad

The Port of Stockholm in Sweden has been building a low-voltage 400V shore power system for cruise ships since 1985. In 2000, the Port of Gothenburg built the world's first 6.6kV, 1250kVA high-voltage shore power system. The ports of Los Angeles, Long Beach, and Oak Harbor in the United States all have onshore power supply systems. Among them, the Long Beach Port Central Port Area Reconstruction Project was implemented in 2017, and the equipment and facilities to provide shore power for berthing ships were also increased; and Oak Harbor invested US$60 million to build a shore power system. All 5 terminals and 25 berths have shore power installations. In terms of the source of shore power, US ports also pay attention to clean power sources. California has passed legislation to vigorously develop clean energy. Its main sources of electricity are clean energy such as hydropower and solar energy. The proportion of thermal power is extremely low. Port shore power is the main application of solar power generation, which can reduce carbon emissions from the ground up.

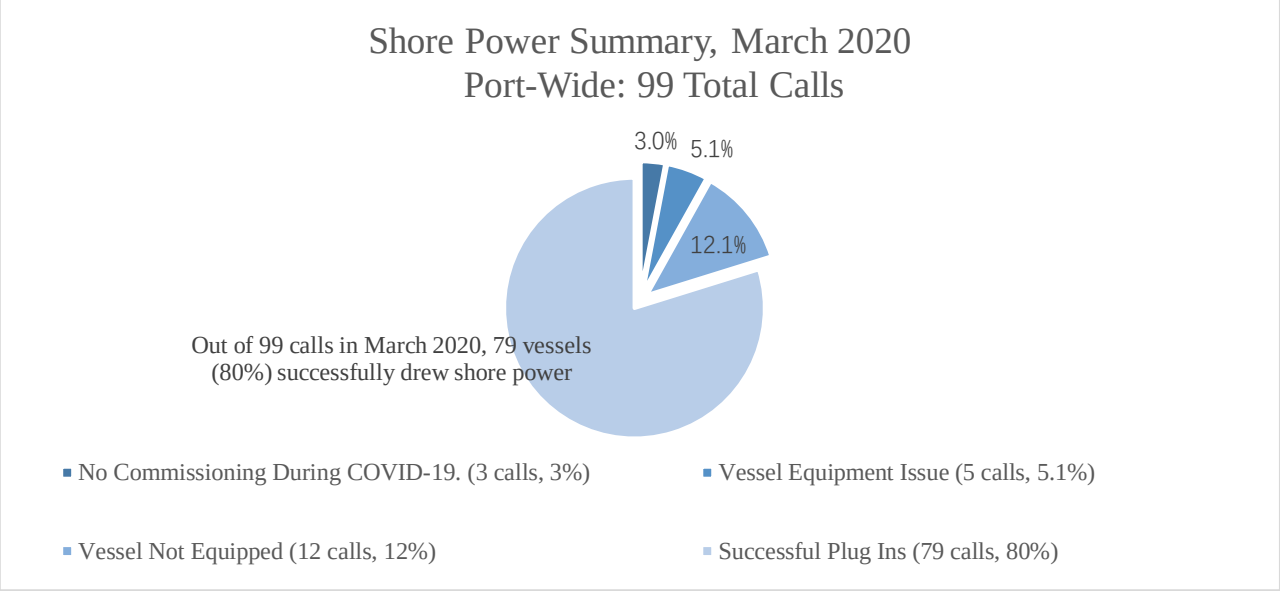

Figure 1. Shore Power Summary, March 2020, Port-Wide: 99 Total Calls

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In 2008, the California Air Resources Board (CARB) passed new regulations requiring the reduction of air pollutants emitted by containers, cruise ships and refrigerated cargo ships docking at six California ports. The main requirements of the regulations include: reducing emissions by 50% from 2014, 70% from 2017, and 80% from 2020. The amount of emission reduction required by the grant funds granted to the port is higher than the emission reduction required by CARB regulations. As shown in Figure 1.

5. Port shore power system type

According to the industry standard JTS155-2012 "Technical Specifications for the Construction of Wharf and Ship Shore Power Facilities" issued by the Ministry of Transport: "Shore-to-ship power supply system (abbreviation: SPS)" means "from shore The power supply facility provides power to ships, and the overall equipment is called shore power facility for ships and docks. The electrical parameters of the shore-side electrical equipment on the shore and the ship-side electrical equipment must be consistent when the ship is connected, including voltage, frequency, and phase angle before power transmission is allowed.

Existing shore power projects are direct power supply from the port power grid to the ship power grid, mainly including low-voltage ship/low-voltage shore power/60 Hz direct power supply scheme, low-voltage ship/high-voltage shore power/60 Hz direct power supply scheme and high-voltage ship/high-voltage shore power /60 Hz direct power supply scheme, as shown in Table 4. It is worth noting that since the frequency of my country's port power grid is 50 Hz, while foreign ships generally use 60 Hz, it is very necessary to realize 50 Hz/60 Hz dual-frequency power supply.

Table 4. Comparison of three typical shore power supply methods

	Pressure ship/low-voltage shore power/60 Hz	Low-voltage ship/high-voltage shore power/60 Hz	High-voltage ship/high-voltage shore power/60 Hz
Marine distribution voltage	440V	440V	6.6KV/11KV
Shore power voltage	440V	10KV	6.6KV/11KV
Shore power	2.5MVA	2.5MVA	7.5MVA
Port grid frequency	60Hz	50Hz	60Hz
Ship grid frequency	60Hz	50Hz	60Hz
Shore power connection	ship provides power system	ship provides cable	ship provides cable
Air pollution	No	No	No
Power supply operability	poor, multiple cables, difficult to connect	well, one cable, easy to operate	good, less cables, easy to operate
Ship transformation complexity	general	complicated	general
Typical port	Port of Los Angeles	Port of Gothenburg	Seattle Container Terminal

6. Benefit analysis of port shore power system

6.1 Economic Benefit Analysis

6.1.1 Port fees

The cost of the port's shore power transformation is mainly the expansion and expansion of the power supply system of the terminal, the cost of setting up the shore power system and the cost of management, operation and maintenance. The expansion and expansion of the terminal power supply system and the installation cost of the shore power system mainly include equipment and equipment costs, civil construction costs, labor costs, and auxiliary materials costs. Management, operation and maintenance costs mainly include labor costs, equipment maintenance costs and electricity prices. The facilities for shore power transformation mainly include cables, transformers, switch cabinets,

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frequency conversion equipment, and shore power boxes. Zuo Qiang (2016) In the "Research on Technical Schemes of Port Ship Shore Power System", starting from the existing terminal conditions, existing load and installed capacity, he calculated the shore power demand of the ships calling at the port and studied the ship based on the port power grid situation. The feasibility of connecting shore power system, the technical proposal, through research and analysis, show that the ship shore power system can reduce the cost of power supply of ships, can save the equipment maintenance cost of using auxiliary machinery for power generation, and can improve the efficiency of the port. Wu Zhao (2018) used the analytic hierarchy process and fuzzy evaluation method in the "Port Ship Shore Power System Design and Economic and Social Benefit Analysis and Evaluation" to comprehensively and comprehensively analyze the economic and social benefits that the port shore power system can bring. The evaluation shows that the use of shore power systems in ports can bring considerable economic benefits. JANKEVICS (2012) et al. stated in "The development of the ships shore power supply system on the passenger port of Riga" [8] that the shore power system will reduce ship fuel consumption, equipment maintenance and crew costs. FANTAUZZ (2016) et al. conducted a complete cost-benefit analysis in "Cost/benefit analysis of alternative systems for feeding electric energy to ship sin port from ashore" [9] by considering all costs related to the system that can use external systems to provide electrical energy to ships. In particular, it will evaluate the economic benefits of cold perm, LNG power plants and fuel cells to obtain the economic benefits of using shore power technology when ships dock.

6.1.2 Ship benefit analysis

According to the data of related papers, the fuel consumption rate of ship auxiliary engines is about 0.5kg/kWh. The fuel consumption rate is multiplied by the annual electricity consumption to get the total annual diesel consumption. The annual fuel cost of the ship can be calculated according to the diesel market price: If calculated according to the 0# diesel fuel of 6300 yuan/t, the fuel cost per kilowatt-hour of electricity is 3.15 yuan/kWh, and the ship's shore power is calculated at 1.6 yuan/kWh. The income is 1.55 yuan/kWh (If the ship uses heavy oil, the price of heavy oil is generally 0.54 times that of clean oil, which is converted to the oil cost per kilowatt-hour of 1.7 yuan/kWh). Usually, a 150,000-ton ship docked at the dock for 48 hours, and if all shore power is used during the docking period, it can reduce fuel consumption by 2.1 tons and reduce expenditure by 5,000 yuan.

6.2 Social Benefit Analysis

Improve the working environment of dock workers. Terminal shore power technology can solve the noise problem of diesel generators, reduce noise during docking, improve the production and living environment of crew and terminal staff, and embody the "people-oriented" concept. For example, the Port of Charleston in the United States has not only reduced pollution to the surrounding environment through the use of shore power, but also dockers have clearly felt the improvement in the quality of the working environment. The following table 5 shows that the Port of Charleston has reduced emissions after using shore power ratio.

Table 5. Standards and greenhouse gas emissions reduced through the use of shore power at the Port of Charleston

Pollutant	Percent Reduction Using Shore Power
Carbon Monoxide (CO)	92%
Nitrogen Oxides (NO_x)	98%
PM10	59%
PM2.5	66%
Sulfur Dioxide (SO_2)	73%
Carbon Dioxide (CO_2)	26%

Through the use of shore power technology, the quality of the urban environment can be improved, and the benefits of energy saving, emission reduction and environmental protection are outstanding.

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According to incomplete statistics, all kinds of ships above 1,000 tons each consume about 3 million tons of fuel during berthing and loading and unloading at Chinese ports. If shore power is used instead, the country can reduce carbon dioxide emissions by more than 9 million tons and sulfur dioxide emissions each year. About 100,000 tons, and about 200,000 tons of nitrogen emission reduction, this is of great significance to the national and global energy conservation and emission reduction work.

In summary, the construction of shore power systems in ports and the use of shore-based power supply by ships have good economic efficiency. At the same time, they have great emission reduction effects and significant social benefits, which are worthy of vigorous promotion.

7. Problems and suggestions in the development of port shore power

7.1 There is a problem

7.1.1 The problem of mismatch between ship and port shore power

Because there are certain differences between the power system of our country and the power system of international sailing ships, the standard system of domestic shore power system should be continuously improved and in line with international standards, although there are domestic transportation industry standards for a certain range of ship shore-based power supply system construction. Requirements, but as an industry standard, the effectiveness of the standard is not strong. Therefore, during the construction and use of shore power facilities, there are certain problems: the capacity selection of shore power facilities; the construction of shore power facilities systems; the compatibility of ship-to-shore communication protocols; the matching of ship-to-shore protection functions ; Adaptability of terminal electrical equipment to environmental conditions, etc.

7.1.2 The high cost of shore power construction for ships

The high construction cost is the biggest resistance to the use of shore power. The use of shore power system not only needs to be modified on shore-based power supply facilities, but also the corresponding facilities on ships also need to be modified before they can be used. The world’s first large bulk carrier to install shore power equipment--"Fuqiang China", the ship’s total investment in the transformation of shore power facilities is about 6 million yuan, of which equipment investment is about 3 million yuan, although the annual fuel cost can be saved nearly About 600,000 yuan, but the investment payback period is 10 years, and the long-term use cost of shore power facilities is relatively high.

After ships are equipped with power receiving equipment and facilities, operating costs are high. For example, the shore power rate adopted by the Port of Oakland, the rate and cost include an hourly usage fee of US$267 (plus applicable taxes), a maintenance fee of US$31 per hour (plus applicable taxes) and the initial commissioning fee for the vessel is USD 3,600.

7.1.3 The problem of marine fuel

Due to the lack of effective supervision in the marine fuel market, the oil quality cannot be guaranteed. Moreover, the current international oil price is relatively low. Compared with the use of low-priced and inferior fuel oil on the market, the operating cost of ships connecting shore power does not form a clear comparative advantage. Considering that large ships need to be modified, ships connecting shore power work affected. According to the U.S. Environmental Protection Agency's 2017 "U.S. Port Shore Power Technology Assessment" report, shore power is economically attractive only when the cost of ship fuel is higher than the local electricity price.

7.2 Related suggestions

7.2.1 Unified technical standards

Departments such as transportation and energy have strengthened the coordination and connection of standards, accelerated the improvement of key industry standards and specifications, and promoted the coordination of standards among industries and between ports, ships, and electricity. Implement the requirements of the Air Pollution Prevention and Control Law of the People's Republic of China,

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revise and improve relevant laws, regulations, and standards, and unify shore power charging rates and methods of shore power at various ports. Accelerate the convergence of domestic and international standards, ship power receiving and shore-based power supply equipment and facilities, and formulate standards for shore power system inspection and testing, shore power facility construction, etc.

7.2.2 Introduce relevant subsidy policies

Strengthen the top-level design to increase the utilization rate of shore power facilities. The state formulates laws and regulations that ships calling at ports must use shore power. At the same time, it is clear that newly built ships must be equipped with power receiving facilities, old ships must be modified, and penalties are imposed on ships that fail to use shore power in accordance with regulations; local financial departments should study And formulate a new round of support and support policies related to shore power technology, further expand the scope of subsidies for shore power facilities construction, improve subsidy standards for construction and use links, simplify the approval process for shore power facilities construction, and improve the construction of shore power facilities by port companies and shipping companies. Electricity positivity. A certain amount of financial subsidies will be given to the construction of onshore power supply systems and the transformation of ship power receiving facilities and equipment, and some financial subsidies will be given to ships using shore power systems according to the amount of electricity used. At the same time, the construction of on-shore power supply facilities in ports and the transformation of power receiving facilities on ships have been simultaneously promoted to increase the enthusiasm of ships to use shore power at ports and promote the development of shore power systems.

7.2.3 Strengthen the supervision of the marine fuel oil market and improve the electricity supply/ sale mechanism

Relevant departments should strengthen the supervision of the marine fuel oil market, so that some low-priced and inferior oil cannot be circulated normally; ports should increase the relevant departments for power supply/sales.

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