

## Analysis and enlightenment on the development of ship shore power in Chinese and American ports

Xiuju Han<sup>1,a</sup>, Yongfeng Zhang<sup>1,2,b</sup>

<sup>1</sup>School of Transportation, Shanghai Maritime University, Shanghai 200000, China;

<sup>2</sup>Shanghai International Shipping Institute, Shanghai 200000, China.

<sup>a</sup>2353494650@qq.com, <sup>b</sup>mouse5172@163.com

---

### Abstract

With the global environmental standards and requirements higher increasingly, the concept of "green port" construction is deeply rooted in the hearts of the people. In recent years, with the strong support of the authorities, the development of Chinese ports' ship shore power supply system has reached a certain scale, but in fact, the actual utilization rate is low. This article by comparing with American ports, analysed the inadequacies of Chinese ports, learnt from American successful experience, and combined with actual problems encountered in application and promotion, finally, gave China suggestions for develop ship shore power further. That is, government needs to take compulsory measures to encourage both the port part and the ship part to improve the utilization rate of ship shore power, and increase financial support, formulate ship shore power industry standards promptly, and joint all departments to promote ship shore power development.

### Keywords

Port, ship shore power, development suggestion.

---

### 1. Introduction

China possesses numerous ports, in recent years , the environmental pollution problem become more and more serious, especially when ships calling ports, which use the traditional way of auxiliary power for electricity, cause the exhaust gas pollution seriously. Set the port of Shanghai as an example, according to a ship emission test results of port in 2010, the emission of SO<sub>2</sub>, NO and PM2.5 from ships calling at Shanghai port accounted for 12.0%, 9.0% and 5.3% of the total air pollutants in Shanghai respectively[1]. So, the Chinese government strongly advocates the development of ship shore power technology.

Ship shore power technology refers to stop the traditional way of power supply , which use auxiliary engine burning fuel for power, and replace it with the clean way of use the ship shore power to supply the power required by its pumps, ventilation, lighting, communication and other facilities [2].To develop the ship shore power is an important measure to reduce carbon emissions from the source, and need to be seriously considered. In recent years, under the guidance of relevant government departments, some ports have built available ship shore power facilities, however, due to some reasons, the use of it is not satisfactory. After nearly 20 years of development, American ports' ship shore power has got a very good grades, and the ports in California is most outstanding, according to the information provided from the port of Auckland, its ship shore power utilization rate has reached 75% in 2018. In order to promote the development of ship shore power of Chinese ports furtherly, the article took the ports of California, which represent the highest development level of ship shore power in US ports, as an reference, compared and analyzed the differences between Chinese and

California ports in terms of ship shore power application, related policies and economic incentives, then based on the specific situation, put forward the suggestions for the further development of ship shore power of Chinese ports.

## 2. The development of ship shore power in California port

### 2.1 The present application of ship shore power

Since 2004, the ports of California have applied ship shore power at container terminals, cruise terminals, oil terminals, and bulk cargo terminals, and adopted different power supply system according to the kind of each berth and the type of calling vessels.

In 2004, the Port of Los Angeles applied the ship shore power technology to the No. 100 berth of the container terminal for the first time, it offered 60Hz direct supply and low-voltage shore power to low-voltage ships. In 2007, Los Angeles proposed to switch to 6.6KV high-voltage shore power to supply the ocean-going vessels [3]. In 2011, the Port of Los Angeles successfully installed 6.6kV/11kV high-voltage ship shore power, with a power supply capacity of 40MVA, which can provide 20MW power for a single ship[4]. In 2009, Long Beach Port applied the ship shore power technology to the oil terminal for the first time. In 2010, the promulgation of California "At-berth" law promoted ports to construct ship shore power faster. At the beginning of 2013, 20 of the 60 berths that required to equip the ship shore power system by the "At-berth" law which scheduled to take effect on January 1, 2014, have been equipped, and only 6 berths had not been equipped by the end of 2013. In addition, in order to meet the requirements of the "At-berth" law, related shipping companies have successively retrofit ships which need calling at California ports, deployed ship receiving systems and started to use ship shore power. For example, in 2014, Maersk Line equipped its 16 vessels which calling at California ports regularly, with a power receiving system (the cost of each ship beyond 1 million US dollars).

### 2.2 The issued policies and laws

California promotes calling vessels to use the ship shore power in a step-by-step approach, and carries out in a clear route and schedule. The California government actively plays the role of the upper-level guidance. First, the ship should use the shore power when it calls the terminal with shore power supply capacity. Then, the terminal that is required to provide the calling service for the ship that transports the specified goods must build shore power equipment, and finally introduce legal to enforce ships that transport the specified cargo must use shore power when they call the ports.

In February 2007, the *California Environmental Protection Agency's Air Resources Board (CARB)* proposed a percentage of annual ship shore power utilization for vessels which calling the six ports (Los Angeles, Long Beach, Oakland, San Diego, San Francisco and Winnipeg) of California, including container ships, passenger ships, and refrigerated cargo ships, since 2010, the utilization should reach 20%; since 2015, reach 60%, and since 2020, reach 80%[5].

In December 2007, CARB approved the "At-berth" regulation, which mandated that the auxiliary engines of ocean-going vessels should reach the corresponding emission reduction requirements in several stages. The first stage is from January 1st, 2010, ships that calling terminals with ship shore power supply capacity must use ship shore power, and pollutant emissions should be reduced by at least 10%. The second stage is from January 1st, 2012, reduced by at least 25%. The third stage is from January 1st, 2014, reduced by at least 70%. In the fourth stage, after 2020 reduced by at least 80%.

In October 2010, California added the above-mentioned "At-berth" regulation to California law (referred to as "At-berth" Law). The Law provides two options for ocean-going vessels that calling at the California ports to meet the mandatory emission reduction requirements. One way is to close auxiliary diesel engine, and use other sources of power, the most feasible is to use ship shore power. The other way is to use alternative control techniques that can achieve the same reductions. In order to ensure the utilization of ship shore power, the port authority signed an agreement with the shipping

company, stipulating that the rate of times the ship use ship shore power when calling, during 2014-2016 should reach 50%, during 2017- 2019 should reach 70%, and after 2020 should reach 80%. For those who fail to meet the above requirements, each calling will be fined \$1,000 ~ \$75,000 dollars depending on the situation. By 2018, the port of Los Angeles, Long Beach, and port of Auckland both have possessed ship shore power supply systems, and the utilization rate in Los Angeles and Long Beach has reached 80%[6]. In addition to the mandatory requirements for ships to use ship shore power, the "At-berth" law also imposes mandatory requirements on constructing ship shore power facilities, requires that the terminal should report the plan of reconstruct or build ship shore power supply system to the government department before the scheduled date[7].

### 2.3 The Economic incentives

In addition to the legal enforcement for the use of port ship shore power, California has also promoted the use of port ship shore power through subsidies and some economic incentive plans and emission taxes.

In 2004, California implemented a "cold call" program, required ships to close their marine generators after calling at the terminals and switch to use ship shore power. In order to carry out this measure, California began to grant calling subsidies to ships those using ship shore power. Meanwhile, from 2015, began to implement a penalty on ships which do not use ship shore power, and each time they call at the terminal, a fine of 25,000 US dollars will be imposed. For port enterprises, the California government publicizes and instills the "early concept", implements subsidy policies for ports in ship shore power retrofit projects. The subsidy for each terminal is 3 million US dollars. If the task is completed in advance, the government will allowance another 1.5 million US dollars [8].

## 3. The development of ship shore power of Chinese ports

### 3.1 The present application of ship shore power

According to data from The China Waterborne Transport Research Institute, by the end of June 2018, Chinese ports had built more than 2,400 sets of ship shore power supply systems, covering more than 3,200 berths, and completed about 40% of the tasks proposed in *The Port Ship Shore Power Layout Scheme*, and the Beijing-Hangzhou Canal Water Service Are basically achieved the full coverage of the ship shore power supply system. the construction of the ship shore power supply system has been developed from the individual and single berth to systematic and full berth [9].

In 2009, Qingdao port completed the retrofit of the shore power of the 5,000-ton domestic trade feeder container terminal, which is the first beneficial attempt of the application of shore power of Chinese ships [10]. In March 2010, Shanghai port waigaoqiao ii applied the mobile variable frequency transformer power supply system to several berths, achieving 50Hz/60Hz dual-frequency power supply [11]. In the same year, lianyungang implemented the construction of high-voltage ship shore power system in China for the first time, and applied it to the "China-Korea star" postal ship. The shore power system has a capacity of 1.5mva and an output voltage of 6.6kv, and can provide 50Hz/60Hz dual-frequency power. In December 2011, the ship power system of 200# berth of the second-phase expansion of huanghua port was put into use. The system adopted three-phase four-line power output of 6kV/50Hz. In September 2016, the shore power system jointly developed by lianyungang and Shanghai port was put into use in Shanghai yangshan port, and successfully supplied 18h of power to Taiwan Eva's 8000TEU container ship "changqing"[12]. As of February 2018, Shanghai port has built 20 sets of ship shore power supply facilities, covering 26 berths.

Not only ports started to equip ship shore power supply facilities, some shipping companies have also began to install ship shore power receiving equipment. The shipping named "Shenhua Zhonghai" has retrofitted its 46,000 DWT dry bulk carriers for high-voltage ship shore power; Lianyungang China-Korea Ferry Co., Ltd. has retrofitted the shore power receiving system of its "China-Korea Star" cruise to connect the high-voltage ship shore power of Dalian Port. In addition, some new ships have also begun to equip shore power receiving equipments.

Although many ports of China have possessed the ability to offer ship shore power, however, in fact the utilization rate is low. Most of the ship shore power facilities and ship power receiving facilities have not been used after commissioning, and this facilities is seriously idle. According to relevant surveys, the ports that actually use ship shore power in 2017 are mainly Lianyungang Port, Ningbo Zhoushan Port, Nanjing Port and Wuhan Port. In the ocean-going vessels that equipped ship shore power receiving facilities, only the "China-Korea Star" use the ship shore power most frequently [13].

### 3.2 The issued policies and documents

In 2015, the new revised *Air Pollution Prevention and Control Law* proposed that "the new terminal should plan, design and construct ship shore power supply facilities, the completed terminal should gradually install ship shore power supply facilities. And the calling ships should give priority to ship shore power". The country began to promote the development of ship shore power of port from the top to down, but the requirements and the targets were not clearly enough.

In 2017, The Ministry of Transport issued *the Port Ship Shore Power Layout Scheme*, it clearly put forward that "by 2020, more than 50% of the five categories of specialized berths of major ports that have been built, including containers, cruise ships, passenger ships, 3-kiloton or above passenger ships and 50,000-ton or above dry bulk cargo, shall have the capacity to provide shore power", and the type of the berths, time nodes and expected effects for the construction of shore power facilities of ships were defined.

In 2018, the revised *The Regulations of Administration of Port Engineering Construction* further implemented the requirements for the simultaneous construction of ship shore power facilities at new terminals and gradual retrofit the ship shore power at existing terminals.

In 2019, in order to promote the use of ship shore power, six departments including the Ministry of Transport and the Ministry of Finance are joint to formulate and issue *The Notice on Further Promoting the Use of ship shore power by Ships calling at Ports (Notice)*, which emphasizes standardized the construction of ship shore power. And intends to promote the normalization and facilitation of use ship shore power in many aspects, while urges to accelerate the construction of ship shore power supply systems of ports.

Table 1 Major Shore Power Policies Issued by the Chinese Government during the 13th Five-Year Plan Period [9]

Title	Years	Departments	emphasis contents
13th Five-Year Ecological Environmental Protection Plan	2016	the State Council	To Establish Ship Emission Control Zone in waters of the Pearl River Delta, Yangtze River Delta, the Regions of the Bohai, and Beijing-Tianjin-Hebei. And 90% harbor and official ships of the main ports should use ship shore power, 50% of specialized container, passenger and cruise terminals could supply ship shore power. And Priority should be given to ship shore power for vessels calling at ports.
13th Five-Year Energy Saving And Emission Reduction Comprehensive Work Plan	2016	the State Council	To strengthen the guidance of the policy of central financial power in ship shore power incentive funds and promote the construction of ship shore power facilities in ports, water service areas, and anchorage sites.
The Guidance On Promoting Alternative Energy	2016	The eight ministries including the National Development and Reform Commission	To strengthen the guidance of the policy of central financial power in ship shore power incentive funds and promote the construction of ship shore power facilities in ports, water service areas, and anchorage sites.

Port Ship Shore Power Layout Scheme	2017	The Ministry of Transport	By 2020, more than 50% built berths of the major ports, including containers, cruise ships, passenger rolls, passengers above 3,000 tons and dry bulk cargoes above 50,000 tons, shall have the ability to provide ship shore power.
The Opinions On Innovating And Improving The Price Mechanism For Promoting Green Development	2018	the National Development and Reform Commission	To clarify that the ship shore power operator that implements the two-part tariff will no need to pay capacity electricity fee before the end of 2025.

### 3.3 Economic incentives

In terms of subsidy policies, during the "Twelfth Five-Year Plan" to the "Thirteenth Five-Year Plan", the Ministry of Transport and the ministry of finance jointly issued *Interim Measures On The Management Of Special Funds For Energy Conservation And Emission Reduction In Transport , Guidelines For Apply Award Funds For The Use Of Port Ship Shore Power By Ships In 2016 -- 2018 Year* and other guidelines, to promote the application of ship shore power in ports. For example, *The Guidelines For Apply Award Funds For The Use Of Port Ship Shore Power By Ships In 2016 -- 2018 Year*, which encourages the port to "construct early", stipulates that whose ship shore power facilities built in 2016 can apply for 60% facilities subsidies; built in 2017 can apply for 50% facilities subsidy; built before March 31, 2018 can apply for a 40% facilities subsidy.

In 2015, the Ministry of Transport invested 1.15 billion yuan for special funds to subsidize ports the ship shore power projects. Subsequently, the Ministry of Transport according to *The Ship Shore Power Distribution Scheme Of Port* issued in 2017, indicated that will invest 740 million yuan for the construct and retrofit ship power facilities of 245 projects from 2016 to 2018. Besides, it also issued *The Opinions On Innovation And Improvement Of The Price Mechanism For Promoting Green Development*, clarified that "at the end of 2025, the ship shore power operators in port that implements the two-part tariff will be free in capacity electricity fee.

Not only the higher authorities have issued various incentive policies, but also port cities have tried to implement various incentives for the construction or use of ship shore power. In 2017, shenzhen issued *The Interim Measures On The Management Of Subsidy Funds For The Construction Of Green And Low-Carbon Ports In Shenzhen*. So far, shenzhen is the only port city in China that provides subsidies for the use of ship shore power to ship owners. As of June 2019, a total of 75.5568 million yuan of subsidies have been paid for using ship shore power. Shanghai has issued *The Ship Shore Power Supply Pilot Program Of Shanghai port Of calling international Ships*, offer subsidies for the construction of shore power facilities, power expansion fees, electricity tariffs, and operation and maintenance fees caused by the use of shore power by the ships.

## 4. Comparative analysis of the development of ship shore power between Chinese and California ports and enlightenment for China

### 4.1 Analysis of ship shore power development between California ports and Chinese ports

Firstly, compared with the construction of ship shore power in California, it can be found that although China has built many ship shore power facilities, the actual use of ship shore power is not optimistic. From the policy of promoting the ship shore power development of ships, there is a lack of strong measures to promote the use of ship shore power for ships calling ports. Therefore, the relevant departments need to introduce mandatory policies, and rise into the law, from the top to promote the calling ships use ship shore power.

Secondly, although the relevant departments attach great importance to the promotion of ship shore power, but there is still a lack of a clear road map and schedule. Both ports and ships need a specific spot of time to determine which stage needs to be developed to what extent and strictly implement it. Finally, it is necessary to increase financial subsidies. Most of the current financial subsidies are only for ports, and there are fewer incentives for calling vessels which use ship shore power. Thus, it is quite necessary to take effective measures to encourage calling ships use ship shore power.

Table 2 Comparison of development of ship shore power between China and California

Comparison project	California	China
Completed ship shore power facilities	At the beginning of 2013, 20 of the 60 calls that needed to be equipped with ship shore power supply system were equipped with the supply capacity, by the end of 2013, only 6 calls had not been equipped with port ship shore power supply system. By 2018, ships berthing at the ports of Los Angeles, Long Beach and Oakland all installed ship shore power supply systems.	By the end of June 2018, China had built more than 2,400 ship shore power supply systems, covering more than 3,200 calls, and 40 percent of the power facilities in major ports and zones within emission control. At the same time, shipping companies have completed the reconstruction of about 358 (3,000-ton or above) ships receiving electricities, accounting for less than 1% of the total number of ships.
The situation of ship shore power usage	By 2018, the Port ship shore power utilization of Los Angeles Port and Long Beach Port has reached 80%, and the Oakland port has reached 75%.	Currently, the ports that really use ship shore power are mainly Lianyungang port, Ningbo Zhoushan port, Nanjing port, Wuhan port, Shanghai port and Shenzhen port, and even in Shenzhen with relatively good development, the use proportion of ship shore power is still less than 10%.
Related guidance policy	"At-berth" law - the number of times a ship uses port ship shore power during calling should reach 70% in 2017-2019 and 80% after 2020.	The Ship Shore Power Distribution Scheme Of Port- 5 types of specialized calls such as containers, cruise ships, passenger rolls, passengers above 3,000 tons and dry bulk goods above 50,000 tons should be available for ship shore power by 2020
The situation of financial policy support	Granting subsidies for calling ships for use shore electricity. A subsidy policy be implemented for port electricity reconstruction, the subsidy for each port reconstruction project will cost 3 million US dollars. If	In 2015, the Ministry of Transport allocated 150 million yuan to subsidize port power projects. In the years from 2016 to 2018, about 740 million yuan was awarded to 245 projects for the construction and renovation of port and ship shore power facilities

	the task is completed ahead of schedule, the government will subsidize another 1.5 million us dollars.	
--	--	--

#### 4.2 Suggestions for Chinese ports of ship shore power development

Compared with the development of ship shore power in California ports, and based on the actual situation, the paper put forward some Suggestions for the further development of ship shore power in Chinese ports.

1. Issue relevant laws and regulations as soon as possible, force the ports to supply ship shore power and urge the calling vessels to use ship shore power

As soon as possible through national legislation, administrative law and other forms of mandatory provisions on port construction of ship shore power facilities, in order to promote it develop faster, and get the scale coagulation effect. In addition, for calling ships, the use of ship shore power should also be mandatory. Both domestic ships and foreign ships that calling at Chinese ports should be required to use it, and it is best to ensure the full implementation by legal means.

2. Learn from the successful experience of California, combined with the actual situation give the route and schedule for the promotion of ship shore power

Although the relevant departments have continuously refined the development goals of ship shore power for port, at present, there is still a lack of clear route and schedule. Therefore, related research institutes are required to conduct on-the-spot investigations on the development of ship shore power of Chinese ports, and should adopt differentiated development requirements for new and old ports with different conditions, or coastal and inland ports, and learn from the successful experience of California ports, rationally plan the route and schedule for promoting the ship shore power.

3. Improve the ship shore power incentive policy and encourage ports and calling vessels to participate in ship shore power application

Firstly, it is necessary to solve the shore electricity price problem, and give consideration to the interests of both the port side and the ship side. At present, the price of shore electricity is much higher than that of diesel power generation in many places. From the perspective of shipowners, shore electricity is not dominant, and shipowners are not very enthusiastic to use it. Policies such as "large industrial electricity price shall be implemented by the shore power operator, and capacity electricity fee shall be free" should be implemented as soon as possible, and adopt preferential policies of electricity consumption for ships using shore power, and discounts shall be given for using electricity when exceed a certain amount. In contrast, from the perspective of the port side, according to the relevant policies, the port side needs to charge the electricity price from the ships at a low price, and the income does not cover the expenditure, so need to increase the price difference subsidy to the port side. Secondly, it is necessary to increase the subsidy of civil engineering reconstruction and equipment maintenance expense, the existing special funds for ship shore power projects only include equipment purchase fees for ports, and the port part have to bear the excess huge amount of expenses on themselves, so need to increase subsidies to improve the enthusiasm of ports to develop ship shore power.

4. Unifying the standards of the ship shore power industry and promoting the faster development of ship shore power

At present, China lacks ship shore power industry standards, not only the interface standards between the receiving and supplying devices are not uniform, but also in ship shore power equipment operation. First of all, most of Chinese ships adopted low voltage power supply system, and many ports also adopted low voltage ship shore power connection system, but at present only for high voltage shore connection system with related standards, the low voltage ship shore power connection system hasn't formulate relevant standards, need to study and formulate relevant standard as soon as possible.

Secondly, there is no unified standard for ship shore power operation, and the process of connecting ships to ship shore power is not standardized. As the Long Beach study suggests that connecting a vessel to shore power would take between 20 minutes and two hours, and disconnecting it would take similarly long[14]. Thus, unified standards need to be formulated to prepare for ship shore power connection in advance, improve work efficiency and further promote the development of ship shore power.

5. Cooperate with ship part, port part and relevant authorities to promote the development of ship shore power

The development of ship shore power of ports involves ship owners, port owners, transportation, environmental protection and other departments, so it is necessary to establish a joint group to promote the development. Coordinate the work of ship owners and port owners, plan and cooperate with each other to ensure that the ports which can provide ship shore power, work together with ships which with electric equipment, and improve the utilization rate of ship shore power. Transport, environmental protection and other competent departments need to work together to issue relevant policies and promote the development of ship shore power.

## References

- [1] Yuefeng D. Current Application and Prospects for Shore Power System of Shanghai Port. Public Utilities, Vol. 27 (2013) No. 5, p. 36-38,63.
- [2] Xin T, Liu Y, Zhiyuan C, et. Summary of Development of On-shore Power Supply for Vessels Technology in China and Abroad. Smart Grid, Vol. 2 (2014) No. 11, p. 9-14.
- [3] Tetra Tech, Inc. Draft Use of Shore-Side Power for Ocean-Going Vessels White Paper.American Association of Port Authorities and Port of Los Angeles, 2007.
- [4] Jian T, Jun H, Sanrong G, et. Development and application of shore power supply system. Journal of Shanghai Maritime University, Vol. 38 (2017) No. 3, p. 90-95.
- [5] Chuansheng P. Drawing on the Experience of California in the United States to Promote the Use of ship shore power by calling vessels. Port Economy, (2016) No. 2, p. 10-13.
- [6] Overview of Green Development of Ports in California, USA. Science & Technology of Ports, (2018) No. 6, p. 40-42.
- [7] Chuansheng P. Discussion on Promoting the Use of ship shore power by calling Ships. Port Economy, (2015) No. 9, p. 17-21.
- [8] Liping L, Yuanyuan L, Jia G. Prevention and Control Experiences of pollution from vessels and ports in United States and Suggestions for China. Environment and Sustainable Development, Vol. 42 (2017) No. 5, p. 111-115.
- [9] China Shipping Network. Top-level design: from construction layout to use guidance. 2019.
- [10][http://info.chineseshipping.com.cn/SEB/SEBWeekly/ALL/201905/t20190528\\_1321137.shtml](http://info.chineseshipping.com.cn/SEB/SEBWeekly/ALL/201905/t20190528_1321137.shtml)
- [11]Mingchao L, Yumei L, Qiang S, et. Development and Application of Technology for Shore Power Supply for Vessels in Port in China and Abroad. Port Engineering Technology, (2012) No. 3, p. 41-44.
- [12]Xiao Y. Environmental and economic Benefits of vessels using shore-power. Fudan University, Shanghai, 2013.
- [13]Shaohua Y, Hanjiang Y. Ship shore power system of Chiwan Container Terminal. Science & Technology of Ports, (2018), p. 14-18, 25.
- [14]Current Status and Suggestions on Port Power Construction and Use in China. Science & Technology of Ports, (2018) No. 8, p. 11-12,30
- [15]Vaishnav Parth, Fischbeck Paul S, Morgan M Granger, et. Shore Power for Vessels Calling at U.S. Ports: Benefits and Costs. Environmental science & technology, 2016.