Issues and Enlightenment of China's Port Shore Power Development from the Perspective of Multiple Streams Theory

Jiashao Zhang, Weixi Zeng, Chengyan Zeng

School Of Public Affairs And Administration, University Of Electronic Science And Technology Of China, Chengdu, Sichuan Province, China

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Abstract: As an important measure of port city environmental governance, port shore power is facing the challenge of sustainable development. Innovative policy tools must be adopted to promote development. Based on the Multiple Shore Theory model, this paper discusses the current significant problems in the development of China's port shore power from the problem flow, policy flow, and political flow. It also deeply analyzed the profit and loss calculations and game of the major stakeholders in the use of shore power in China. Finally, from the perspective of policy leaders, the paper puts forward appropriate policy tools that can take into account the interests and concerns of local governments, shipping companies, ports and power grid companies, and increase the utilization rate of port shore power to improve port environmental governance.

1. Introduction

On September 10, 2013, the State Council of China issued the Air Pollution Prevention and Control Action Plan, which clarified the timetable for air pollution control in China, thus opening a new historical process for the long-term prevention and control of air pollution in China.

Ports are an indispensable part of contemporary transportation and freight transportation. Among them, the exhaust gas from the operation of auxiliary machinery of ships calling at ports is the most important source of pollution. In order to ensure the normal operation of the ship and the operation of auxiliary machinery during the berth, the ship uses fuel oil to generate electricity. When it is used, a large amount of sulfide, nitrogen oxide and particulate matter are generated. These pollutants not only damage the human body, but also greatly damage the terrestrial aquatic environment. In 2005, the State of California investigated the pollutant emissions of ships in all ports in the area. The results of the investigation showed that pollutants such as sulfide, nitrogen oxides, particulate matter and carbon monoxide emitted by ships at berth accounted for about 3/5 of the emissions of the annual pollution of ships in the port [1], which was far exceeds the amount of pollutants emitted by ships in port when they were moving or passing by. It can be seen that the pollution caused by the power generation of gas turbines from ships calling at the port is enough to seriously threaten the ecological environment of the port city and the health of residents.

Port shore power, as shown in Figure 1, refers to the use of power from the shore port power supply system to replace the ship's own fuel auxiliary engine to supply power to the overall equipment used by the ship at the port after docking, so as to meet the power demand of the ship and realize ships' "zero emissions" at harbor. Comparing the energy consumption and emissions of a ship's 1kWh self-generation and 1kWh shore power, it is found that the use of 1kWh shore power can reduce ship energy consumption by 6.7%, and reduce sulfur dioxide and nitrogen oxide emissions by 45.9% and 67%, respectively. It shows that port shore power has a significant effect on the prevention and control of port air pollution [3].

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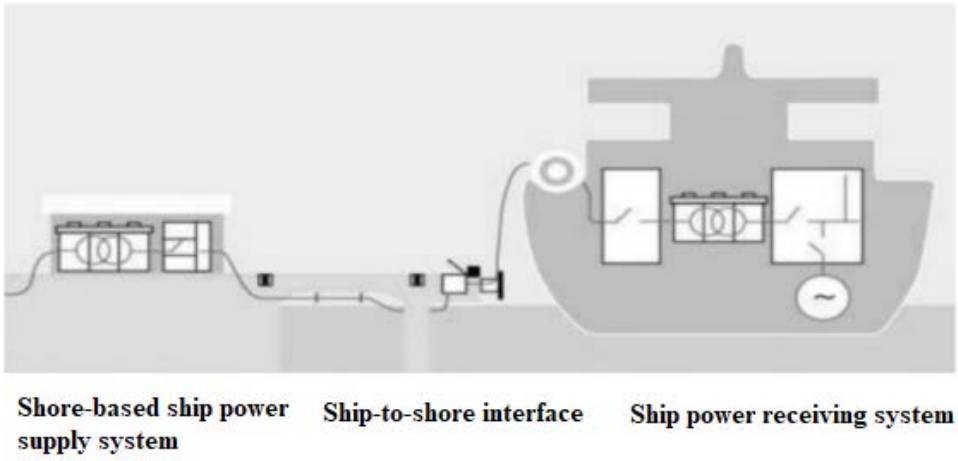

Fig.1 Operating Principles of Port Shore Power Facilities [2]

2. The Framework of Multiple Streams Theory and Its Applicability

With the rapid development of policy science, based on the Garbage Can Theory model, as well as a large number of interviews and case studies, kingdon proposed the multiple streams framework [4] believes that the emergence of an agenda is not the effect of a single factor, but is often due to the result of a combination of these factors at a specific moment [5]. As shown in Figure 2, these complex factors are actually three sources after sorting, namely Problem Stream, Policy Stream and Political Stream. When the three sources converge, “policy window” will be opened, which will further promote the formulation and reform of important policies or the resolution of problems. In Multiple Streams Theory, the Problem Stream refers to the public problem that needs to be paid attention to by the government and solved by action. It is a stream formed by the convergence of real social problems. Political Stream needs to examine factors such as public sentiment, political parties, interest groups, government changes, etc., involving the influence of various interest groups on the solution to the problem. Policy Stream generally refer to related solutions or policy recommendations for a certain social problem, as well as existing policy programs. Judging from China's research of Multiple Streams Theory, the academic circles continue to try to apply it, mainly in the fields of social security, housing, education, environmental protection, etc [6]. This shows that the theoretical framework is applicable in China as a whole. In addition, port shore power in China’s was born and developed under the guidance of relevant policies by the state. However, Chinese scholars in this field mainly conduct research from the perspective of technology and economy, and the research on the perspective of government and policy is relatively lacking. Therefore, from the perspective of government policy, it is necessary to clarify the problems in the development process of China's port shore power development based on the Multiple Streams Theory, which is very necessary for the improvement and implementation of the policy system related to the development of China's port shore power.

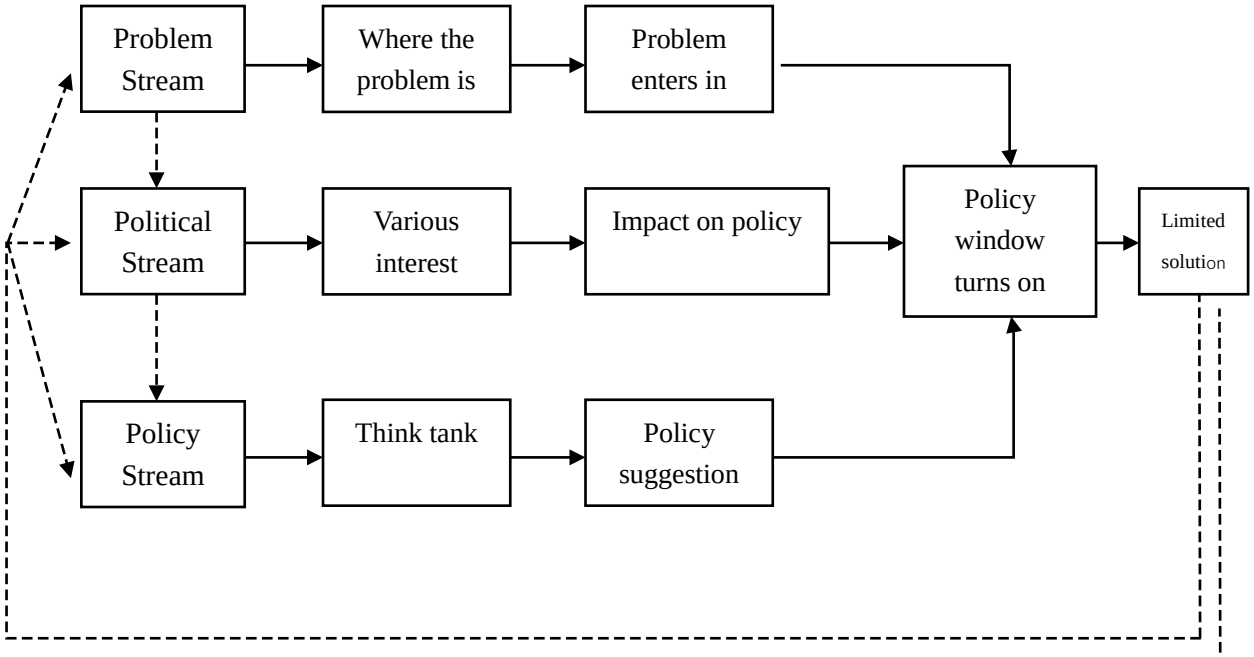

Fig.2 Problem Analysis Model from the Perspective of Multiple Streams

3. Analysis of Problem Stream, Political Stream and Policy Stream in the Development of China's Port Shore Power

3.1 The Problem Stream of Port Shore Power Development in China: the Overall Dilemma

At present, the problems of shore power development in China's ports are mainly focused on the construction technical specifications and sustainable operation of shore power in ports, which has led to the most important issue of shore power utilization, which urgently needs policy makers to pay attention and solve [7].

On the one hand, some key technical specification issues in the construction of China’s port shore power have not yet been resolved. First of all, there are differences between the technical specifications for China's port shore power construction and the international technical specifications. The power supply frequency of China's onshore power grid is 50Hz, which is incompatible with shore power and ocean-going ships in countries such as Europe, America, Japan, South Korea and other countries with a power supply frequency of 60Hz. This has caused great difficulties for shipping companies to transform ships [8].

On the other hand, the problem of sustainable operation of shore power in established ports has come one after another. From the perspective of overall operating costs, the operating problems of China's established port shore power are mainly reflected in the high comprehensive cost of shore power operations. The cost involved in the port shore power operation process by the port and shipping companies is very huge, and it is difficult to recover the cost without proper government subsidies and the actual situation of economic downturn [9]. In addition, in terms of overall operation technology, there has not yet been a feasible unified standard for the daily operation and management of the ship's shore power system.

3.2 The Political Stream of China's Port Shore Power Development: an Analysis of Stakeholders

The current issue of shore power development in China is mainly focused on the use of shore power, which involves the handling of relationships between various stakeholders. The interest groups involved in the development of port shore power include the government, shipping companies, port terminals, and power grids. The following is an analysis of the current situation of the four interest groups in view of the low utilization rate of shore power.

3.2.1 Government

The government is a promoter, coordinator, and regulator in the construction and operation of shore power. The most important consideration is the overall social benefits. However, in the process of promoting shore power development, it has still failed to resolve industry standards, subsidy mechanisms and laws. The protection of these three key issues has led to a low utilization rate of shore power.

First of all, in the construction technology of port shore power, the state and the Ministry of Transport have issued many relevant documents, but they are more instructive, and policies and industry standards for addressing inconsistencies in domestic and foreign shore power construction standards are relatively lacking. The targeted construction specifications issued by the Ministry of Transport are mainly composed of JT/T 814-2012 *Technical Conditions for Port Ships Shore-based Power Supply System*, T/T 815-2012 *Port Ships Shore-based Power Supply System Operation Technical Regulations* and JTS 155-2019 *Technical Specifications for the Construction of Terminal Shore Power Facilities*. Among them, the power supply frequency of the onshore power grid is 50Hz, which is incompatible with shore power and ocean-going ships in countries such as Europe, America, Japan, South Korea and other countries with a power supply frequency of 60Hz. Although the newly developed 50 Hz/60 Hz power can also be carried on the traditional inverter supply, but cannot meet the requirements of shore power.

Furthermore, in terms of policy subsidies for the construction and operation of port shore power, local government subsidy standards and mechanisms vary, and a linkage mechanism has not yet been formed. Even in China's two neighboring cities, Guangzhou and Shenzhen, there are still huge differences in the amount and details of their subsidies.

The last but not the least, the use of shore power at ports lacks legal protection and accountability. On the one hand, there are related accidents during the use of shore power at Chinese ports, but there are no corresponding laws and regulations as the basis for liability determination and compensation. On the other hand, the construction and operation of shore power in China's ports lack relevant accountability systems. Under the situation of unclear government supervision, it is difficult for shipping companies to consciously use shore power in ports.

3.2.2 Shipping Companies

Shipping companies are the actual users of shore power in ports, and they are also the key players in the sustainable operation of shore power. They mainly consider issues from the perspective of economic benefits.

The first consideration for ships adopting shore power is the huge cost.

On the one hand, the high cost of transformation has made shipping companies discouraged from embarking on shore power. The data shows that, under normal circumstances, the ship cost for the shore power receiving transformation of foreign cruise ships and ferries is about 500 thousand US dollars, while the transformation cost of container ships is about 3 million yuan [9]. On the other hand, the high cost of operation makes it difficult for shore power to get on board. The service charges levied by port operators on ships in different regions of China are very different. In addition, the maintenance cost of the additional ship’s equipment to connect shore power, the cost of connection and the cost of shore power training, make shipping companies adopt a more negative attitude.

In addition, for a long time, ships have used heavy oil and marine fuel for power generation, and the connection of shore power facilities is complicated and time-consuming, which to a certain extent harms the navigation efficiency of the shipping company. If it is not mandatory to use shore power or take effective assistance measures, most shipping companies will not actively use shore power.

3.2.3 Port Terminals

The port terminal is the direct operator of shore power, and its behavior is directly related to the use of shore power by shipping companies. The main considerations are shortening the recovery period of shore power costs and guiding ships to form stable shore power consumption habits.

Shore power has a huge construction cost, and the port has a long period of time to recover its

cost. Shore power transformation involves a complete set of equipment, such as variable frequency power supplies, cable junction boxes, marine substations, etc. The cost of a berth is close to 5 million. Such a huge cost investment makes port and terminal companies eager to recover costs, otherwise the external economic situation will be more difficult. Under poor circumstances, the vulnerability of its capital chain will continue to increase. However, in order to sustainably operate and promote the use of shore power, the port's pricing of shore power must be kept at a low level. Low shore power pricing makes the port terminal's shore power supply side less motivated, and try to reduce operating costs. This leads to the port terminal neglecting the ship side when providing shore power services, reducing the quality of shore power services, and increasing the dilemma of low utilization rate of shore power.

3.2.4 Power Grids

In the construction and operation of port shore power, the costs related to the construction of the distribution network and the comprehensive costs (including construction and management costs) of the power substitution project are borne by the port. Power grid company is not responsible for the cost of shore power facilities. They get Profit from electricity bills at almost zero cost. This free-riding behavior aggravated the negative sentiment of the shore power supply side of the port terminal, and the sense of unfairness made the Hong Kong side reduce the trust in the power grid side, and it was difficult to cooperate with the power grid side’s technological improvement behavior, making the cost of shore power high, which indirectly led to the difficulty of shore power promotion.

3.3 Policy Stream of China's Port Shore Power Development: Policy Plans

In response to the development of shore power in China's ports, Chinese scholars have made great breakthroughs in technical thinking and applied research, but they are still lacking in government and policy research, especially in the research on shore power utilization.

From the perspective of technical feasibility, in China, Cao Shanwen had already put forward specific technical management opinions on ship’s shore power connection in 1995 [11]. In 2013, Wu Zhenfei and other experts pointed out that the key technology of ship shore power is in power supply, the system does not match the problem, and related improvement techniques are proposed for this problem [12].

From the perspective of economics and program feasibility, in 2016, Lin Jieqing and Song Jiexia analyzed the investment model of port marine shore power system based on charging standards and clarified the practical feasibility of port ship shore power system transformation at this stage [13]. In 2020, Wu Junni, Lyu Jing and others built a three-stage game model for the port emission reduction system with the government, ports and shipping companies as the game participants, and concluded that the use of shore power facilities has good environmental and economic benefits [14].

3.4 “Policy Window” Has Opened for China's Port Shore Power Development: Limited Solutions

With the interaction of technical specifications, capital costs and other issues involved in the construction and operation of port shore power, emerging policy plans, and various interest groups, the “policy window” for the development of China’s port shore power has gradually opened. Various guiding ideologies, industry construction norms and operational policy support for the development of shore power in China continue to emerge.

At the legal level, the *Air Pollution Prevention and Control Law of the People's Republic of China (2018 Amendment)* promulgated in 2018 has laid a good foundation for the legalization and standardization of shore power construction and development. At the level of guiding policies, the “*Thirteenth Five-Year” Comprehensive Work Plan for Energy Conservation and Emission Reduction* and the *Three-Year Action Plan for Winning the Blue Sky Defense*, which were successively released by the State Council from 2016 to 2017, established related goals and directions for the construction of shore power in China’s ports. In addition, from 2011 to 2019, the Ministry of Transport issued more than a dozen port shore power guidance policies, such as the

Port Shore Power Layout Plan, *Port and Ship Shore Power Management Measures*, etc. These policies are mainly for the implementation of the construction goals of port shore power, the technical specifications of the shore power industry and the start-up operation have been guided, but the problems of the standardization and sustainable operation of shore power technology have not been systematically resolved.

All in all, in the past ten years, China's port shore power related policies have further established the status of shore power, promoted the standardization of China's shore power facilities, and promoted the basic coverage of its port shore power facilities. At the same time, the main contradiction has gradually transitioned from construction to operation. The core problem has also fallen on the use of shore power. Therefore, the opening of the "policy window" of China's shore power will focus on the use and sustainable operation of shore power in the future.

4. Policy Enlightenment for the Sustainable Development of Shore Power in China's Ports

At present, the main contradiction in the development of shore power in China's ports is focused on the use and sustainable operation of shore power, and the main problems are focused on various interest groups. Therefore, the following will give corresponding policy recommendations from the perspective of policy leaders, aiming at reasonable policy methods adopted by various interest groups.

4.1 Shipping Companies: Multi-Management Policy Tools

First, use reasonable economic tools to promote shore power on board.

First of all, in order to shorten the payback period of the investment in the shore power transformation of shipping companies, the government can provide phased subsidies for ships using shore power and subsidies for special transportation tariffs for ships that regularly call at ports. Furthermore, in response to the huge differences in shore power subsidies and prices, local governments should establish a linkage mechanism for shore power prices and related subsidies, and establish a reasonable guide price for shore power supply and sale. Finally, the cost analysis model can be combined to analyze the cost of each part of the shore power on board to form a reasonable financial subsidy mechanism.

Second, strengthening the willingness of shipping companies to use shore power through persuasion and guidance. The government can organize shipping industry associations and related organizations to promote and educate the use of shore power, promote shipping companies to protect the environment and then adopt a sense of moral obligation to adopt shore power, and increase their willingness to adopt shore power.

Third, urging shipping companies to use shore power through compulsory means. For example, California of the United States stipulates the proportion of the number of shore power used by shipping companies to the total number of berthings. If the required ratio is not met, the ship will be fined from one thousand to seventy-five thousand US dollars according to the actual situation when berthing [10].

4.2 Ports and Power Grid Companies: Economic Means and Administrative Means Go Hand in Hand

On the one hand, the government can improve the quality of shore power services at ports and terminals through a combination of various economic means such as tax incentives and subsidies, and indirectly increase the utilization rate of ship shore power. For example, the government can establish financial subsidy policies linked to shore power service quality and shore power utilization rate, increase the enthusiasm of ports and terminals to operate shore power, and give more attention and convenience to shore power business. On the other hand, the PPP model is adopted to solve the problem of funding shortages during the construction and initial operation of shore power facilities at ports and piers. In addition, through the introduction of contract energy management mode, the construction of shore power system can be invested and implemented by grid companies first, and then share the benefits of shore power operation to reduce the investment risk and financial pressure

of port and terminal companies [15].

4.3 The Government Itself: the Improvement of Laws, Regulations and Supervisory Mechanisms

On the one hand, in terms of protection of laws and regulations, the government should promulgate corresponding shore power insurance regulations from the perspective of terminal, port, and terminal shore power operators, ships, and waterway operators to dispel the doubts of interest groups from all parties [16]. On the other hand, in terms of the regulatory mechanism, it is necessary to implement the regulatory scope and supervision authority of the various levels of transportation management departments and maritime management agencies on the stakeholders of shore power [17], establish a rule-based accountability system, and implement the usage of shore power through administrative supervision.

5. Conclusion

Through the analysis of multi-source flows, it can be seen that the sustainable development of China's port shore power mainly focuses on the four major stakeholders of the government, shipping companies, ports and power grids. The key to the development of shore power is to implement the use of shore power and establish a sustainable operation mechanism [18].

Therefore, from the perspective of government and policy, a combination of compulsory and voluntary tools should be used to enhance shipping companies' willingness to use shore power and make it a continuous behavior in shore power use [19]. Financial subsidies and administrative methods should be used to promote technological innovation in ports and power grids, reduce the cost of shore power operation, improve port shore power service quality, and promote the use of shore power. In addition, the government should provide corresponding legal guarantees for the implementation and sustainable operation of shore power, and gradually establish a corresponding insurance system. At the same time, the government should also strengthen supervision, escort the sustainable operation of shore power, and promote the usage of shore power well and quickly.

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