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# Carbon Emission Measurement and Low Carbon Development Countermeasures in Guangzhou Port

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## Abstract

**Low carbon at home and abroad for reference,the experience and practice of port construction,based on fuel consumption activities consume electricity consumption and ship port carbon emissions measurement method,calculate the carbon emission level of the guangzhou port results show that in recent years,guangzhou port of CO2 emissions form for shipping activities consumption accounts for about 55%,accounted for about 33% of electricity consumption,low fuel consumption accounted for about 12% of the final combined with guangzhou carbon port construction situation and existing problems,from the technical management legal system and cultural aspects of low-carbon port development strategy is put forward.**

## Keywords

**Harbor environment; Carbon emission measurement; Low carbon strategy.**

## 1. Introduction

Port is an important pillar industry in the development of the world economy, but it is also one of the main units of carbon emissions. The construction of low-carbon port is of great significance to the development of low-carbon economy. In 2016,the Ministry of Communications and Transport issued the 13th Five-Year Plan for energy conservation and environmental protection of transportation, which clearly proposed that the comprehensive energy consumption and carbon dioxide emission of the throughput per unit of port production in China should be reduced by 2%[1] In such a macro context, ports, as the major carbon emitters, are duty-bound in low-carbon development. As one of the important ports in the world, Guangzhou Port plays an important role in the port system of our country. The realization of the low carbonization development of Guangzhou Port can not only enhance the competitiveness of the port and promote the development of regional economy, but also have important reference significance for the low carbonization development of other ports in China.

## 2. Current status of carbon emission research in ports

At present, foreign scholars have a more comprehensive research on low-carbon ports and carbon emissions, and domestic related research is still relatively scattered, mainly through the analysis of domestic and foreign port low-carbon development experience and the current situation and shortcomings of low-carbon port construction in China, the use of qualitative methods to put forward low-carbon port construction and development countermeasures, but actual port carbon emission measurement research results are less. Analysis of domestic and foreign scholars research results, the current carbon emissions research guidance documents are mainly the following three types:

(1) Greenhouse gas agreement. The agreement, developed jointly by the World Resources Institute and the World Business Council for Sustainable Development, provides a more comprehensive greenhouse gas measurement standard and calculation framework, which is internationally

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recognized as an industry standard for determining corporate greenhouse gas emissions responsibilities and is currently a more commonly used carbon emission measurement tool in countries around the world.

(2) Air quality and greenhouse gas tools.is a tool system developed by the international port association. based on port reality, the system gives the relationship between air and climate change and ports and relevant information. it proposes some relevant strategies to reduce carbon emissions and guidelines for the development of clean air projects and climate protection programs. At the same time, the corresponding solutions to the problems of port air quality and climate change are put forward.

(3) Carbon footprint guidance document. The carbon footprint guidance document, developed jointly by the World Port Climate Initiative and a number of ports, is designed to provide technical guidance to ports working to develop their own carbon footprint accounting methods.

Greenhouse gas agreement provides a more comprehensive greenhouse gas measurement standards and calculation framework, widely adopted by the world, easy to be used in the actual port production process of carbon emissions measurement, this paper uses the relevant standards GHG agreement to carry out research.

## 3. Guangzhou Port Carbon Emission Measurement System

### 3.1 Overview of Guangzhou Port

Guangzhou port is the largest integrated main hub port in South China, With good geographical location and natural conditions, Is a multi-functional, comprehensive, modern deepwater harbor, Pearl River Delta has the world's advanced level of modern integrated logistics service hub. January-November 2018, Guangzhou port cargo throughput 570 million tons,5.2% year-on-year increase; Container throughput,20.016 million TEUs, A year-on-year increase of 7.5%, Cargo throughput and container volume ranked fourth in coastal ports,7th place in the world. Guangzhou Port Group is the leading logistics enterprise in South China. Port transformation and upgrading are being accelerated. In the Xinhua Polo Sea International Shipping Center Development Index, Guangzhou International Shipping Center rose to 18th place in 2018,No .4 in my country[2] .Since 2005,the annual throughput of Guangzhou Port has continued to increase, and the corresponding fuel consumption, electricity consumption and the number of ships arriving at the port each year also show an increasing trend, resulting in the energy consumption of Guangzhou Port area is also increasing year by year, as shown in Table 1:

Table 1 Statistics of Fuel, Electricity and Arrival Vessels in Guangzhou Port 2009-2017

| Year | Fuel consumption(tons) | Power consumption (thousands of watts) | Number of ships arrving |
|---|---|---|---|
| 2009 | 24756.8 | 11542.0 | 6984 |
| 2010 | 25961.6 | 12152.9 | 7985 |
| 2011 | 26087.3 | 12287.4 | 9640 |
| 2012 | 27097.9 | 13794.3 | 10921 |
| 2013 | 30854.8 | 15873.6 | 11012 |
| 2014 | 31629.0 | 17295.2 | 11879 |
| 2015 | 32192.6 | 18825.3 | 12909 |
| 2016 | 33710.4 | 20912.6 | 13872 |
| 2017 | 341215.5 | 22149.5 | 15621 |

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In December 2009, China officially announced the goal of reducing the intensity of carbon dioxide emissions by 40-45% from 2005 to 2020, and the 2015" Enhanced Action to Combat Climate Change – China's National Independent Contribution ", submitted to the United Nations, has set the goal of peak carbon dioxide emissions by 2030 and reaching the peak as soon as possible, marking a gradual shift from relative emission reduction to zero growth [1]. Port as a large carbon emissions, energy conservation and emission reduction responsibility is particularly significant. In this regard, Guangzhou Port has gradually increased the research and development of energy conservation and emission reduction in the port. In the past ten years, Guangzhou Port has implemented a series of energy conservation and emission reduction projects, and has carried out a lot of work in low carbon sustainable development.

## 3.2 Guangzhou Port Carbon Emission Measurement System

### 3.2.1 Accounting scope of Guangzhou port carbon emission

The GHG agreement defines three ranges for measuring corporate carbon emissions: first, direct emissions from corporate production activities, mainly fossil fuel consumption; The second is indirect emissions from the consumption of electricity by enterprise activities. The third is indirect emissions except the second type. This paper mainly calculates port carbon emissions from the three ranges of port fuel consumption, electricity consumption and ship activities. The objects included in the different ranges are as follows:

Port fuel consumption. Including gantry cranes (including gantry and cantilever type), traditional tire gantry cranes, heaps and other mechanical equipment and trucks, trailers and other transport vehicles fuel consumption, this does not include the ship power generation, operation and other processes of fuel consumption. furthermore, the port fuel consumption is mainly diesel oil, and gasoline is not used much and based on the collected data. here, the $CO_2$ amount emitted by the port diesel fuel consumption is mainly calculated [3].

Port power consumption. Including electric tire crane, rail crane, shore container crane and other production machinery equipment that need to consume electricity, lighting, office building, warehouse, unpacking place, operation area and so on in the port operation and management process to consume the scope of electricity, machine repair, sewage treatment, ventilation, inspection vehicle weighing and other operation process of electricity consumption, as well as the port daily management operation and other facilities to consume electricity[3].

Ship activities. These include carbon dioxide emitted by ships in Hong Kong during waiting, loading and unloading operations, etc., by generating electricity from their own fuel for their operations. Although Guangzhou Port has been promoting the use of shore power in recent years, but the current use of shore power ships are only a small number, most of the affiliated ships still rely on their own fuel to generate electricity for their operations, so this paper does not consider the use of shore power [3].

### 3.2.2 Accounting method for port carbon emission

According to the above accounting range of port carbon emissions, this paper mainly calculates port carbon emissions from the three parties of fuel consumption, electricity consumption and ship activities.

(1) Calculation formula for carbon emissions from fuel consumption.

The amount of $CO_2$ emitted by port fuel consumption can be calculated by formula (1):

$$E_F = \Sigma C_{Fi} \times F_{Fi} \quad (1)$$

$E_F$: Amount of $CO_2$ emitted by port's annual total fuel consumption (t).

$C_{Fi}$: Type i annual fuel consumption (t).

ISSN: 2414-1895 DOI: 10.6919/ICJE.202009_6(9).0013

$F_{Fi}$: Type i fuel emission factor (t CO2/t).

Note: The emission coefficients of all types of fuels can be calculated according to the calorific value and the proportion of $CO_2$ emissions per unit calorific value. If the $CO_2$ emission coefficient per unit calorific value is missing, the default $CO_2$ emission value of corresponding fuel unit calorific value can be determined by referring to IPCC Guidelines for National Greenhouse Gas Inventory 2006. Therefore, the $CO_2$ emission coefficients of diesel and gasoline in Guangzhou port are determined to be 3.150t $CO_2$/ t and 3.045t $CO_2$/t respectively.

(2) Calculation formula for carbon emissions from electricity consumption.

The amount of $CO_2$ emitted by port power consumption can be calculated by formula (2):

$$E_E=(C_E\times F_E)\div 1000 \quad (2)$$

$E_E$:Amount of $CO_2$ emitted by port's annual total power consumption (t);

$C_E$:Annual total port power consumption (KW·h);

$F_E$:$CO_2$ emission factor of port power (kg $CO_2$/ kW·h)

Note: The power of Guangzhou port mainly comes from thermal power, and its CO2 emission coefficient is 1.0523 kg $CO_2$/ kW·h.

(3) Calculation method of carbon emission from ship activities.

The amount of $CO_2$ emitted by port-to-port ships can be calculated by formula (3):

$$E_{ST}=(Q_{ST}\times F_{ST})\div 1000 \quad (3)$$

$E_{ST}$: The amount of $CO_2$ (t) discharged by the total annual arrival ship activity at the port;

$Q_{ST}$: Total annual oil consumption of vessels arriving at port (L);

$F_{ST}$: $CO_2$ emission factor (kg $CO_2$/L);

Note: Since the tonnage and time of each ship arriving at Guangzhou Port in the whole year cannot be obtained, only the total number, gross tonnage and total time of ships arriving at Guangzhou Port in the whole year can be obtained. Therefore, this paper calculates the following results according to the relevant statistical data of Guangzhou Maritime Safety Administration and Port Administration bureau: the average time of ships in Guangzhou port is about 48h (the loading and unloading time of 30,000-ton ships is about 36h, and the non-operating time is about 12h). Guangzhou port shipping units for an average of 25000 tons, the average is about 1000 kw power generators, loading and unloading operations in generating 80% computation, when the homework to generating 50% computation, power of 1000 kw generator (mainly diesel generators) power generation efficiency is about 80%, full of fuel consumption is about 290 l/h, according to the above data analysis ships in port 2 days use about 10092 litres per ship. In addition, the $CO_2$ emission coefficient of vessel fuel oil is 2.647kg CO2/L (also equal to 3.150t CO2/ T) [4].

## 4. Analysis of Carbon Emission Measurement Reasultsin Guangzhou Port

### 4.1 Data presentation

According to the annual total fuel consumption, power consumption and the number of ship activities in Guangzhou Port from 2005 to 2013, the carbon dioxide emission of Guangzhou Port was calculated by the above carbon dioxide emission calculation method. The calculation results show that with the increase of fuel consumption, electricity consumption and the number of ships in the port year by year, the corresponding amount of $CO_2$ emission also increases and shows an increasing trend year by year, as shown in Table 2:

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Table 2 Various $CO_2$ emission and Total Emission Scales of Guangzhou Port (unit: ton)

| Year/Various $CO_2$ emission sources | $CO_2$ emissions from port fuel(t) | $CO_2$ emissions from port power(t) | $CO_2$ emissions from ships in port(t) | Total CO2 emissions(t) |
|---|---|---|---|---|
| 2009 | 73352.7 | 114231.6 | 167464.1 | 355230.4 |
| 2010 | 69543.6 | 121400.4 | 230925.1 | 421869.1 |
| 2011 | 75367.6 | 122567.2 | 268753.1 | 467687.9 |
| 2012 | 80365.6 | 131094.8 | 303965.2 | 515425.5 |
| 2013 | 91353.8 | 158543.0 | 337071.2 | 586959.0 |
| 2014 | 92543.7 | 171697.6 | 367965.5 | 632206.8 |
| 2015 | 95503.3 | 189522.3 | 399337.5 | 684363.1 |
| 2016 | 99249.4 | 207153.5 | 453848.9 | 760251.8 |
| 2017 | 102831.2 | 210822.8 | 472829.2 | 786438.2 |

### 4.2 Carbon emission structure and change trend of port

(1) The promotion of energy conservation and emission reduction projects has contributed to a decrease in the proportion of fuel consumption. Guangzhou Port's fuel consumption emission CO2 volume increase is relatively flat and stable, its proportion of total emissions has been declining, from 20.6% in 2009 to 12.8% in 2017, which is closely related to the energy conservation and emission reduction projects actively carried out in Guangzhou Port. During recent years, Guangzhou Port has continuously optimized the energy structure, increased the use of clean energy, and gradually popularized the use of trucks LNG (liquefied natural gas). the average bicycle energy cost of LNG vehicles can be reduced by nearly 20% and the CO2 emission can be reduced by nearly 30% compared with the traditional diesel-driven truck. in addition, the continuous advance of the "oil-to-electricity" project optimizes the driving mode of the gantry crane, replacing the original diesel power generation by direct access to the power grid, and reducing the consumption and use of fossil energy. According to the statistics of Guangzhou Port, the economic effect of these energy saving and emission reduction projects is obvious. In 2018, all the oil conversion work of all gantry cranes was completed in Hong Kong. At present, more than 200 gantry cranes in the port area are all driven by electric power. The total investment in equipment construction and transformation is more than 800 million yuan.

(2) Increased but declining share of carbon emissions from electricity consumption. Guangzhou port electricity consumption emissions of co2 in 2009-2013 relatively flat increase ,2013-2017 emissions of co2 increased, mainly due to the port side continued to promote the "oil to electricity" project. By replacing fossil energy with cleaner electricity energy, a large amount of co2 emissions from fossil energy are greatly reduced. From the structural point of view, although the port power consumption shows a relatively rapid growth trend, the proportion of co2 electricity consumption emissions overall shows a downward trend, from 35.84% in 2009 to 33.1% in 2017, the decline is very obvious.

(3) The rising volume of transport business has led to an increase in the proportion of energy consumption of ships in Hong Kong. As a result of the advantages of ports and the growth of foreign economy and trade, the number of ships coming to Hong Kong has increased sharply in the past decade, resulting in a rising co2 volume and proportion of ships coming to Hong Kong. According to the data, Guangzhou port increased from 6984 ships to 15987 ships from 2009 to 2017, corresponding to the discharge co2 ships in port increased from 160,000 tons to 470,000 tons. Generally speaking, the share of co2 emissions from ships in Hong Kong decreased slightly in 2009, but the overall trend is increasing from 44% in 2009 to 55% in 2017.

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## 5. Low Carbon Development in Guangzhou Port

From the analysis of the carbon emissions of Guangzhou port, it can be seen that the fuel consumption of ships in port and the power consumption co2 port become the main emission sources of port, followed by port fuel consumption. Controlling these three sources is the key to building low-carbon ports. This paper puts forward countermeasures to reduce port carbon emissions from the following aspects:

(1) Scientific operation to improve berth efficiency. The total amount and proportion of carbon emissions of ships coming to Hong Kong is the largest, and the first task of building a low-carbon port is to improve the efficiency of ships' operation during the period of port, thus reducing the carbon emissions of ships in port. Control should be carried out in two ways: on the one hand, ship waiting time should be reduced, port resources should be allocated scientifically, ship stopping and operation order should be arranged reasonably, and the efficiency of ship production and operation in port should be improved; on the other hand, ship energy efficiency should be improved, mainly by promoting shore power technology and other means to reduce the large amount of co2. Generated by fuel power generation by ship consumption.

(2) Promote low carbon technology transformation. We will vigorously promote the development and use of low-carbon technologies and implement technological innovation. Electricity energy is cleaner and lower carbon than fossil energy, so we should further deepen the "oil to electricity" project in port operation, and increase the proportion of electricity consumption in total energy consumption. At the same time, we should gradually promote the use of clean renewable energy such as solar energy and wind energy in combination with the port environment, and vigorously promote the use of low-carbon energy.

(3) Build a low-carbon development management system. To build a low-carbon port, it is necessary to change and optimize the port management mode, actively promote the port management mode from the original extensive to fine transformation, and constantly promote the innovation of the port low-carbon management system. To explore the establishment of a fine low-carbon development management mechanism, the carbon emission control index is stratified to each management unit of the port, and the control is carried out through the budget, and the emission reduction measures are refined and concretized, which is convenient for practical operation and control.

(4) Strengthen the supervision of low carbon port construction. Through the improvement of relevant laws, regulations and industry guidelines to provide a strong policy guarantee for the development of low carbon port. Government supervision departments should actively build and improve relevant policies and regulations for low-carbon port construction, air quality management regulations, etc., formulate and implement industry sector minimum energy efficiency standards and carbon emission standards, regularly calculate and analyze port carbon emissions, and urge ports to promote energy conservation and emission reduction work.

(5) Actively cultivate low carbon port culture. We should actively cultivate low-carbon port culture in strengthening the low-carbon awareness of leaders and employees, perfecting the low-carbon system system, and constructing the image of low-carbon ports, and advocate the concept of energy saving and emission reduction in the work of various departments and links, and promote the formation of the concept of low-carbon development. The cultivation and formation of low-carbon port culture will help to form a civilized and good working atmosphere, promote the work of energy saving and emission reduction in all directions, and effectively reduce the carbon emissions of ports.

## 6. Conclusion

According to the international carbon emission agreement, this paper constructs the carbon emission framework of Guangzhou Port, and calculates and analyzes the carbon emission level of Guangzhou Port from 2009 to 2017. Combined with the current situation of low-carbon port construction, it puts forward the countermeasures of low-carbon port construction from the aspects of technology,

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management, system and culture, which provides a certain reference basis for port enterprises to carry out low-carbon construction and sustainable development.

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