China's Industrial Carbon Dioxide Emission Statistical Report Forms and Information System Based on WebGIS

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Abstract: It is very necessary to design a series of industrial carbon dioxide emission statistical report forms which could be measured, reported and checked. At present, it is very difficult to calculate roundly the carbon dioxide emissions in China. But it is possible to carry out pilot study in industries, such as cement, lime and steel. This research designed statistical report forms and discussed the methods to calculate the overall emissions in the light of manufacturing technologies, carbon dioxide emissions sources, and the indices for calculation. In order to manage and analyze the collected data conveniently, this study tried to develop an information system based on WebGIS to collect enterprises' carbon dioxide emissions information.

Keywords: carbon dioxide emissions; statistical report forms; WebGIS

1 Introduction

In 1994，China's overall emission of greenhouse gases was 3.65 billion tons of carbon dioxide equivalent, among which the proportions of carbon dioxide(CO_2), methane(CH_4) and nitrous oxide(N_2O) were 73.05％, 19.73％and 7.22％ respectively. Thus it can be seen that CO_2 is the main source of greenhouse gases. In 2009, at the 15th meeting of the Parties of "United Nations Framework Convention on Climate Change," China promised that CO_2 emissions per unit of GDP would be cut by 40 to 45 percent below 2005 levels by 2020.

China National Development and Reform Commission declare that the government will study and identify the CO_2 emissions target per unit of GDP of the Twelfth Five Year Plan and disassemble the target to local governments or related industries. In May 2010, China's Ministry of Environmental Protection also said it would try to monitor the greenhouse gases.

Some developed countries point out that China needs a set of CO_2 emissions statistical system with international standards to make the cut of emissions measurable, reportable and checkable. And the present urgent work is to get a good collection of CO_2 emission data. At present it is very difficult to calculate roundly the carbon dioxide emissions in China. But it is possible to carry out pilot study in higher energy consumption areas and high-emission industries. According to the inventory of China greenhouse gases emissions in 1994, the main emissions sources in industrial processes are the manufacturing processes of cement, lime, steel and calcium carbide. Therefore, it is proper to choose preferentially the key industries, such as cement, lime and steel to carry out pilot study.

Since 2009, our research group has began to study the industrial carbon dioxide emissions statistics and carried out the pilot study. The group set down pilot technical line to carry out the pilot study of key industries in Guiyang city and tried to develop a geographical information system based on WebGIS to collect enterprises' carbon dioxide emissions data so that the management and analysis of the collected data could be more convenient. Consequently, this study could provide some references and guidance for the related carbon dioxide emissions statistical work in other places and industries.

2 Research Plan

2.1 Industrial carbon dioxide emissions statistical index

In factories, CO_2 emissions are determined directly by manufacturing equipments, production and material consumption. The position of CO_2 emissions source varies with the manufacturing technologies. By means of establishing the tracer index system of CO_2 emissions process, the background data which are used to calculate the factory's CO2 emissions, include two parts:

(1) The main item: the necessary manufacturing process data to calculate CO_2 emissions.

(2) The auxiliary item: the essential background data which are helpful to understand the factory's CO_2 emissions process

Therefore, beginning with the general manufacturing processes of heat-engine plants, cement plants and steel plants, the research group designed statistical report forms and discussed the methods to calculate the overall emissions in the light of manufacturing technologies, CO_2 emissions sources, and the indices for calculation.

2.2 WebGIS of CO_2 emissions

This study adopted the developing platform of WebGIS, ArcIMS, to design the geographical information system of CO_2 emissions. As ESRI's service issuing product of WebGIS, ArcIMS is mainly used to provide

GIS service on internet. It is a product based on server which provides hierarchical frame structure used to release GIS data and service. With GIS map, data and metadata release tool, ArcIMS could organize more users of internal net or external net to acquire data and browse data. ArcIMS makes it possible that websites could provide GIS data, mutual map, metadata catalog and target GIS application. By applying ArcIMS, users could obtain dynamic map and data through internet, create simple and easily operated application which is map-oriented. Besides, users can also apply the development environment of industrialized standard web pages to set up customer applications to share data with other users and establish GIS portal.

3 Results

3.1 Industrial CO_2 emissions statistical report forms

3.1.1The auxiliary index

The auxiliary indices include the enterprise's name, address, contact and linkman's basic information, as table 1 shows.

Table 1: Auxiliary Index of Industrial CO_2 Emissions Statistical Report Forms

1 Corporate Code		2 Detailed Name of Reporting Unit
3 Former Name		4 Opened Time
	5 Corporation Representative	6 Environmental Contact
name		
Telephone		
Fax		
Zip Code		
7 Detailed Address		
8 Administrative Area's Code		
9 Type of Class Registration		10 Parent Company

3.1.2The main index of power plant's CO_2 emissions statistical report forms

The main sources of CO_2 emissions from power plant are showed in table 2, and table 3 is the report form used to calculate CO_2 emissions.

Notes:

Fuel Type：refers to various fuels used in manufacturing process, and mainly contains coal, fuel and gas.

Fuel Consumption：refers to the fuel's annual consumption of enterprise.

Fuel Low Heating Value: the actual heat released by fuel combustion, except the heat of vaporization of its water vapor.

Table 2: Main Sources of CO2 Emissions from Power Plant

Serial Number	Emission Source
1	CO_2 from Combustion of Raw Coal
2	CO_2 from Fuel Combustion

Table 3: Statistical Form of CO_2 Emissions from Power Plant

	1Fuel Type（ton）	2Fuel Consumption（ton）	3 Fuel Low Heating Value（TJ/KG）	4Burn Rate（%）
Fuel 1				
Fuel 2				
Fuel 3				
Fuel 4				
5 Desulfurization Method				
6Desulfurization Capacity（ton）				
7Carbon Dioxide Capture Capacity				

Burn Rate: the ratio of heat released by fuel combustion to all calorific value calculated by certain heat calculation. It is a very important index to study the extent of fuel combustion.

Desulfurization Method is mainly divided into three types: wet limestone - gypsum (wet method), spray drying desulfurization method (semi-dry method), and circulating fluidized bed method (dry method).

Desulfurization Capacity: the annual desulfurization capacity of the desulfurization method adopted by enterprises.

CO_2 Capture Capacity: the annual CO_2 captures capacity if the enterprise adopts CO_2 capture techniques.

3.1.3The main index of cement plant's CO_2 emissions statistical report forms

The main sources of CO_2 emissions from cement plant are showed in table 4, and table 5 is the report form used to calculate CO_2 emissions.

Table 4: Main Sources of CO_2 emissions from Cement Plant

Serial Number	Emission Source	
1	CO2 from Materials Calcinations	1.1 Clinker Calcinations
		1.2 Dust Calcinations
		1.3Organic Carbon in Raw Material
2	CO2 from Fuel Combustion	2.1Cement Kiln's Traditional Fuels
		2.2 Cement Kiln's Alternative Fossil Fuels
		2.3 Cement Kiln's Biomass Fuels
		2.4 Non-Cement Kiln Fuel

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Notes:

Cement Clinker Output: the enterprise's annual output of cement clinker.

CaO in Clinker: the ratio of CaO to clinker

MgO in Clinker: the ratio of MgO to clinker

Table 5: Statistical Form of CO2 Emissions from Cement Plant

(1) Index of Combustion Emissions Statistics				
	1Fuel Type (ton)	2Fuel Consumption (ton)	3 Fuel Low Heating Value（TJ/KG）	4Burn Rate（%）
Fuel 1				
Fuel 2				
Fuel 3				
Fuel 4				
5CO_2 Capture Capacity（ton）				
(2) Technological Emissions				
1Cement Clinker Production (ton)				
2 CaO in Clinker（%）				
3MgO in Clinker（%）				

3.1.4The main index of steel plant's CO2 emissions statistical report forms

The main sources of carbon dioxide emission from steel plant are showed in table 6, and table 7 is the report form used to calculate CO_2 emissions.

Table 6: Main Sources of CO2 Emissions from Steel Plant

Serial Number	Working Procedure	Type of Emission	Source
1	Sintering	CO_2, CO, SO_2, NOX	Fuel Combustion in Sintering
2	Coking	CO_2, CH_4, CO, SO_2, NO_X, H_2S	Coal's Distillation and Combustion
3	Blast Furnace Ironmaking	CO_2, CH_4, CO, SO_2, NO_X, H_2S	Coke Combustion and Reduction Reaction of Iron Ore
4	Converter/Electric Steelmaking	CO_2, CO, NO_X	Iron Decarbonization/Melting Process
5	Steel Rolling	CO_2, SO_2, NO_X	Fuel Combustion in Heating Process or Heat Treatment
6	Lime Calcinations	CO_2, NO_X	Fuel Combustion in Heating Proess/Limestone Decomposition
7	Self-owned Power Plant	CO_2, SO_2, NO_X	Fuel Combustion

3.2The information system of CO_2 emissions statistics based on WebGIS

3.2.1Functional design

Table 7: Statistical Form of CO2 Emissions from Steel Plant

(1) Index of Combustion Emission Statistics					
	1Fuel Type(ton)	2Fuel Consumption(ton)	3 Fuel Low Heating Value（TJ/KG）		4Burn Rat（%）
Fuel 1					
Fuel 2					
Fuel 3					
Fuel 4					
5 CO2 Capture Capacity(ton)					
(2) Technological Emissions					
1Pig Iron Production(ton)					
2Crude Steel Production(ton)		BOF		EAF	OHF
3 Directly Reduced Iron Production(ton)					
4Slag Production(ton)					
5Slug Production(ton)					
	6Alternative Reducing Agent Type		7 Alternative Reducing Agent Dosage		
(1)					
(2)					
	8 Solvent Type		9 Solvent Dosage		
(1)					
(2)					

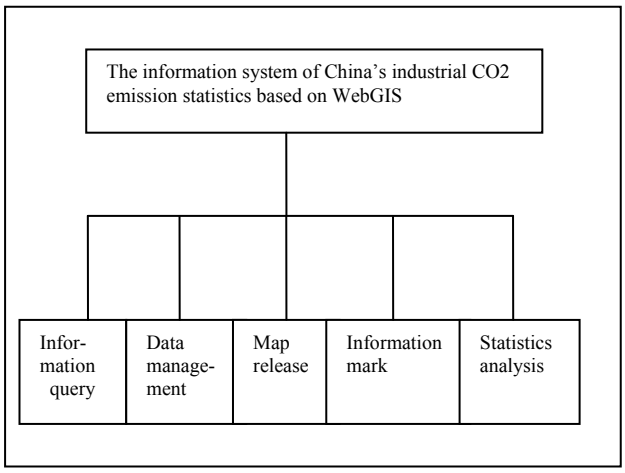

Figure 1: Module Chart of WebGIS Function

This system includes the following four function

modules in figure 1.

Information query realizes user's various data retrieval tasks, including map data retrieval tool and attribute data retrieval tool.

Data management tools are in charge of adding, deleting, modifying, importing and exporting data in the database.

Map release is responsible for making thematic maps based on users' needs and releasing them into the system for the convenience of users' browsing.

Information mark provides descriptions and notes of specific map information for users.

Statistics analysis with statistical index, data collection and calculating formula, this module provides CO_2 emissions statistics analysis for users.

3.2.2 System structure

This system adopts three-layer system structure, showed in figure 2:

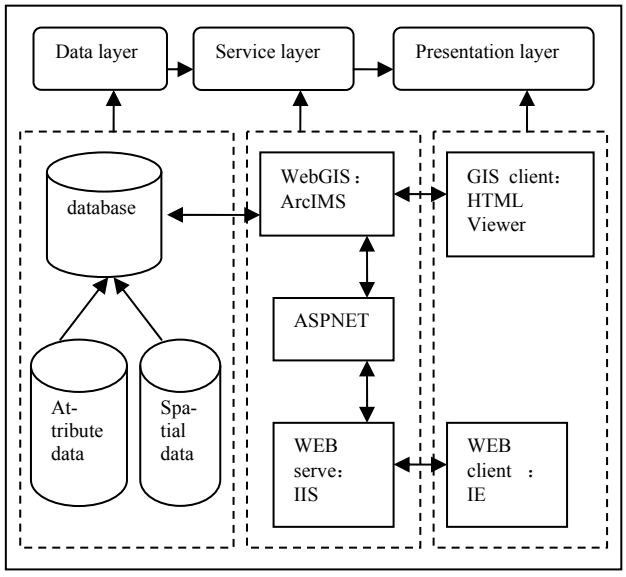

Figure 2: Module Chart of WebGIS Structure[1]

Data layer organizes and manages spatial data and attribute data;

Service layer provides Web and GIS services;

Presentation layer is the function module deployed at the client to reveal the spatial information on the client desktop/device and encapsulates Web client and GIS client. Web client is for ordinary users to view geographical information and GIS client is mainly used to produce and manage maps.

4 Discussion

4.1The discussion of CO_2 emissions' calculating methods.

4.1.1Calculating methods of CO_2 emissions from thermal power industry based on statistical report forms.

According to the data in statistical report forms of CO_2 emissions from thermal power industry, the calculation of CO_2 emissions consists of two parts: combustion and desulfurization.

(1)Combustion emissions, calculating formula:

$$E_{CO_2 \bullet Fi} = FC_{Fi} \times EF_{CO_2 \bullet Fi} \times BR \quad (1)$$

E=emission, F=fuel, FC=fuel consumption, EF=emission factor, BR=burn rate.

(2)Desulfurization emissions, calculating formula:

$$E_{DS} = DSC \times 44 / 64 \quad (2)$$

E=emission, DS=desulfurization, DSC= desulfurization capacity

So, the overall CO2 emission is:

$$E_{CO_2} = \sum_{i=1}^{n} E_{CO_2 \bullet Fi} + E_{DS} - C_{CO_2} \quad (3)$$

E=emission, F=fuel, DS= desulfurization, C=captured.

4.1.2Calculating methods of CO_2 emissions from cement industry based on statistical report forms

According to the data in statistical report forms of CO_2 emissions from cement industry, the calculation of CO_2 emissions consists of two parts: combustion emission and technological emission.

(1)Combustion emissions, calculating formula:

$$E_{CO_2 \bullet Fi} = FC_{Fi} \times EF_{CO_2 \bullet Fi} \times BR \quad (4)$$

E=emission, F=fuel, FC=fuel consumption, EF=emission factor, BR=burn rate.

(2)technological emission, calculating formula:

$$E_T = CP \times CaO\% \times 44 / 56 \quad (5)$$

E=emission, T=technology, CP=clinker production, CaO%=CaO in clinker.

So, the overall CO2 emissions is:

$$E_{CO_2} = \sum_{i=1}^{n} E_{CO_2 \bullet Fi} + E_T - C_{CO_2} \quad (6)$$

E=emission, F=fuel, T=technology, C=captured

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4.1.3Calculating methods of CO_2 emissions from steel industry based on statistical report forms[2]

According to the data in statistical report forms of CO_2 emissions from steel industry, the calculation of CO_2 emissions consists of two parts: combustion emission and technological emission.

(1)Combustion emissions, calculating formula:

$$E_{CO_2 \bullet Fi} = FC_{Fi} \times EF_{CO_2 \bullet Fi} \times BR \quad (7)$$

E=emission, F=fuel, FC=fuel consumption, EF=emission factor, BR=burn rate

(2)Technological emission, calculating formula:

$$E_T = CSP \times EF_S + PIP \times EF_{PI} + DRIP \times EF_{DRI} + SlagP \times EF_{slag} + SlugP \times EF_{slug} + SD \times EF_S \quad (8)$$

E=emission, T=technology, P=production, S=solvent, SD=solvent dosage, EF=emission factor, PI=pig iron, CSP=crude steel production, PIP=pig iron production, DRI=directly reduced iron, DRIP= directly reduced iron production.

So, the overall CO_2 emission is:

$$E_{CO_2} = \sum_{i=1}^{n} E_{CO_2 \bullet Fi} + E_T - C_{CO_2} \quad (9)$$

E=emission, F=fuel, T=technology, C=captured

4.2Increase the efficiency of collecting CO_2 emissions statistics

At present, China has established a set of comprehensive statistical reporting system for environment. Existing statistical report forms (annual or quarterly) contain a large number of index and information. In the process of designing CO_2 emission statistical report forms, the duplication of data collection should be avoided to improve efficiency, and also ensure statistical result. That is the compatibility issue. As for the existing index and information, the study will choose to use in light of the principles and methods of environmental statistical reporting system to improve the efficiency and effectiveness of statistics.

4.3Provide enough industrial CO_2 emissions statistics for WebGIS

Enterprises' CO_2 emissions information's integration with WebGIS can provide consulting services to the public and could be the platform where enterprises and government provide decision-making information. The main faced difficulty is to collect and obtain enterprise's CO_2 emission data. It is necessary to have further cooperation with the environmental monitoring department, to expand sources of data, realize and improve industrial CO_2 geographical information system, and make it play a bigger role in statistics and decision-making of industrial CO2 emissions.

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