Comparative analysis of carbon emissions quota calculation and allocation method for coal-fired power plant in China

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ABSTRACT: With the rapid development of economic globalization and the improvement of people's living standards, and the impact of global warming gradually strengthened. The emissions and trading scheme of carbon dioxide has been widespread concern at home and abroad. The establishment of carbon emissions system and the accounting of the quota in the trading process become the key points. In This paper, the present situation of carbon emissions and its trading system is described, and the carbon emission quotas of a power plant is accounted in different calculation methods of domestic carbon emission pilot cities. The results are compared with the actual quota, and then the comparative analysis of the characteristics of the carbon quota accounting methods in different pilot cities is made, to provide references for further improvement of domestic carbon trading market.

Introduction

The current study shows that the main greenhouse gases include carbon dioxide, methane, nitrous oxide, ground-level ozone, HCFCs, ect. Carbon dioxide is the weakest of greenhouse gases, but the emissions is the largest, accounting for 72% of total greenhouse gas emissions. Besides, the amount of the share of total intensity of radiation of the greenhouse gases is 55%, and degradation time of carbon dioxide in the atmosphere is up to 50 -200 years[1]. It is because the greenhouse effect of carbon dioxide is the most outstanding in all of the six greenhouse gases that its emissions and control becomes a problem of common concern at home and abroad.

Current situation analysis of the international emissions trade

In December 1997, 《Framework Convention》 COP3 meeting was held in Tokyo, Japan, and a total of 149 representatives from different countries and regions reach an agreement on 《Kyoto Protocol》,which is the first to limit greenhouse gas emissions in the form of regulations in human history[2]. From then on, each country has taken a number of measures in many ways, and made positive efforts for greenhouse gas emission reduction.

Table 1: Key elements for pilot schemes

Pilot cities	Industry Coverage	Quota allocation method	Quota allocation method
shanghai	electricity, steel, chemicals, building materials, etc	Free parts of the Carbon emissions quotas of 2013-2015 is given one-time	reference line method
Beijing	Iron and steel, chemicals, electricity and heat, petrochemical,construction etc	Free quota is distributed each year, a small number is set aside for auction of government	Historical method
Tianjin	Iron and steel, chemicals, electricity, heat, petrochemical etc	Mainly for free	reference line method
Shenzhen	Electricity, construction manufacturing etc	Paid and unpaid,and Some quotas is reserved for new entrants	——
Guangdong	Electricity, cement, steel, ceramics, petrochemicals, textiles, paper, etc.	Paid and unpaid,and Some quotas is reserved for new entrants	Historical method and reference line method
Hubei	Iron and steel, chemicals, cement, automobile manufacturing electricity, etc.	For free, and 3% is for regulation of carbon trading market , 15% is for new entrants	Historical method and benchmarking method
Chongqing	Electric power, metallurgy, chemicals, etc.	For free	the emission factor method

Analysis of the development process and the status of carbon emissions trading in western country

In 1999, the EU responded positively to the call of the 《Kyoto Protocol》,and it is the first to began to fulfill the emission reduction obligations. The first greenhouse gas and energy trading simulation system EU-ETS (European Union Emission Trade Scheme)in the world is established[3]. The European Climate Exchange has become the most important carbon emissions trading venues in the world. The well-known includes voluntary transaction of the Chicago Climate Exchange, the Regional Greenhouse gas Initiative, western climate initiative and the California cap-and-trade system. Australia has reached an agreement with the EU on August 28, 2012. The agreement stipulated that the carbon emissions trading system of the two sides will start to be docking on July 1, 2015[4].

Process and Status analysis for the development of emissions trading in China

At present, the number of the expected emission reductions and the number of the CERS in China issued by United Nations are all living in the the first place of the world. Besides, the Chinese government has put forward the target in the "five" plan that the carbon emission intensity of per GDP in 2015 is reduced for 17% compared to that of 2010 [5].The target is decomposed to different provinces as a binding target [6].

Comparative analysis of different methods in carbon trading pilot cities of China for calculation and distribution of quota

Comparition of trading mechanism in the carbon trading pilot cities

Carbon emission of the coal-fired power plant, as CO2 fixed emissions source, is living around 37% of total emissions stably [7]. Currently, the carbon emissions trading markets of the seven pilot cities including Beijing, Shenzhen, Guangdong, Shanghai, Tianjin, Hubei, Chongqing, are all on the line to start the transaction, and the national carbon trading market is planted to be established in about three years.

Take a power plant for an example to calculate the quota in different methods of pilot cities

The basic situation of the power plant

A power plant is taken for an example to calculate the carbon dioxide quota in 2014 in different methods of pilot cities. There are a circulating fluidized bed unit with a capacity of 300MW and a ultra high pressure coal fired unit with a capacity of 125MW.They are both having been put into operation of the emission facilities (unit) before January 1, 2013. The power generation and carbon dioxide emissions in the power plant from 2009 to 2014 is shown in Table

Table 2 CO2 emissions of M Plant 2009--2014

Year	Total carbon dioxide emissions/t	Power generation MWh	Power supply MWh	Emissions intensity MWh
2009	2619249.035	2707765.90	2539884.417	0.9673
2010	2487288.477	2580388.90	2420404.797	0.9639
2011	2351540.264	2449444.56	2297579.000	0.9600
2012	2228326.467	2325727.95	2181532.821	0.9581
2013	2110348.502	2211500.71	2074536.261	0.9543
2014	1998491.116	2102143.03	1974398.176	0.9507

Quotas of M Power plant in 2014 is calculated based on different carbon quota accounting methods in the pilot cities

The carbon emissions quota of the existing facilities in Beijing is calculated based on historical emissions intensity. The average emission intensity of 2009 - 2012 is taken as the standard, and the emission control coefficient of thermal power enterprises was 99.7%。The average carbon dioxide emissions intensity of the power plant for 2009 - 2012 is calculated to be 0.9623t/Mwh according to table 2.

$P=(W\times J)\times f$

$=1974398.176\times0.9623\times99.7\%$

$=1894263.4750t$

Where: P is Quota amount; W is power supply quantity; J is basic emission standard; f is controlling coefficient.

The emission quota of Shanghai electric power industry is calculated in reference line method. The annual comprehensive carbon emissions standard of the power plant in 2014 year is 0.8177 tons / Mwh, according to the type of power plant units and the installed capacity. The correction coefficient is 1,according to the power plant performance and annual load rate.

$$P=J\times W\times m=8.177\times210214.3039\times1$$

$$=1718922.3630\ t$$

Where: P is annual carbon emission quota; J is basic emission standard; W is annual comprehensive power generation; m is correction coefficient.

The quota for the electric power industry in Guangdong Province is calculated in the reference line method. The power generation capacity of the circulating fluidized bed unit with the capacity of 300MW is 1561059.331 MWh, and the reference value is 927 g CO_2/ kWh, and annual descending coefficient is 1. The power generation capacity of the 125MW ultra high pressure coal-fired unit in 2013 is 650441.388 MWh,and the reference value is 965g CO_2/ kWh, and annual descending coefficient is 1.The capacity correction factor of the two units is 0.9506 and 0.9502, according to the ratio of annual generating capacity for 2013 and 2014.

For the power generation capacity of the circulating fluidized bed unit with the capacity of 300MW:

$P_0=W\times J\times n$

$=156105.9331\times10^4\times927\times10^{-6}\times1$

$=1447101.9998\ t$

$P_{01}=P_0\times f$

$=1447101.9998\times0.9504$

$=1375325.7400\ t$

For the 125MW ultra high pressure coal-fired unit :

$P_0'=W\times J\times n$

$=65044.1388\times10^4\times965\times10^{-6}\times1$

$=627675.9394t$

$P_{02}=P_0'\times f$

$=627675.9394\times0.9504$

$=596543.2128$

$P=P_{01}+P_{02}$

$=1375325.7400+596543.2128$

$=1971868.9530\ t$

The free carbon emissions quota in 2014 is:

$1971868.9530\times95\%=1873275.5050\ t$

Where :P_0 is approved carbon emission quota; J is reference value; W is power generation in 2013;n is descending coefficient; P_{01} is actual carbon emission quota for the 300MW circulating fluidized bed unit ; P is the total quota of the power plant in 2014; P_{02} is actual carbon emission quota for the 125MW ultra high pressure coal-fired unit. f is correction factor.

The quota is calculated and allocated comprehensively using the historical method and benchmark method in Hubei province. The adjustment factor is 0.9192.The average historical emissions from 2009 to 2011 is 2486025.926t,and the average power generation is 2579199.792 kWh from 2009 to 2011.Because the actual power output of the power plant in 2014 exceeded 50% of the annual average , additional quota is required to the power plant as an expost adjustment. The benchmark value is 91.931 tons /Mwh.

$P_y=(J\times e)\times 50\%$

$= (2486025.926\times 0.9192\times 50\%$

$=1142577.5160t$

$Pa=\Delta\times b =210214.3039-257919.979\times 50\%\times 9.193$

$=746979.0377$ t

$P=P_{y+}Pa=1142577.5160+746979.0377$

$=1889556.5540$ t

Where :P_y is is approved carbon emission quota;J is historical base of emissions;e is adjustment coefficient; Pa is additional quota; Δ is excess capacity; b is benchmark value; P is the actual quota.

The quota for power industries in Tianjin is calculated in the reference method. The average value in 2013 is decided by the carbon dioxide emissions under normal operating conditions in the 2009 -2012. The unit of the power plant belongs to the existing facilities, and the baseline level of 2014 is determined to be 0.9604t/Mwh, which reduced by 0.2% of the 2013 annual benchmark value. The power plant is given 90% of the average power supply of carbon dioxide emissions according to the benchmark level.

$P_{basic}=J\times W\times 90\%$

$=0.9604\times 2515831.832\times 90\%$

$=2174584.4020$ t

$P_{adjustment}=J\times W-P_{basic}$

$=0.9604\times 2102143.039-2174584.4020$

$= -155686.2273$ t

$P=P_{basic}+P_{adjustment}$

$=2174584.4020-155686.2273$

$=2018898.1750$ t

Where : P_{basic} is the basic quota; $P_{adjustment}$ is the quota for adjustment; P is the actual quota; J is the reference level in 2014; W is the average power generation.

The greenhouse gases approved in Chongqing city contain a total of six major greenhouse gases. The quota of carbon emissions in Chongqing is calculated in the emission factor method. For the power plant :

$P=P_{direct}$

$=AD_i\times EF_{iCO2}+AD_i\times EF_{iN2O}\times GWPN_2O$

Where :P is the P is the total quota;P_{direct} is the quota for direct emission; AD_i is the type of the fuel;EF_{iCO2} is the carbon dioxide emission factor of fuel i ;EF_{iN2O} is the nitrous oxide emission factor of fuel i ; GWP_{N2O} is the Global Warming Potential value of nitrous oxide.

The corresponding emission factors can be get from the appendix B, appendix C of 《 Guidelines for carbon emissions accounting and reporting of industrial enterprises in

Chongqing(Trial)》.The result that $GWPN_2O$=310 can be get from the appendix A of《Guidelines for carbon emissions accounting and reporting of industrial enterprises in Chongqing(Trial)》,and the total quota is 2217615.4325t.

Conclusions

According to the calculation method for carbon emissions quota of power industry in various cities, the results for the carbon emissions quota of the power plant calculated in 2014 is shown in Table 3 .

$$\Delta=P_{actual}-P_{calculated}$$

$$\theta=(P_{actual}/P_{calculated})\times100\%$$

Where :Δ is the amount of quota deviation;θ is the P_{actual} is the actual quota;$P_{calculated}$ is the calculated quota.

Table 3 Comparison of calculation quotas and actual quota for carbon emissions

Calculation method	$P_{calculated}$ t	P_{actual} t	Deviation rate %
actual	1998491.117	—	—
Beijing	1894263.475	104227.6417	5.2153
Shanghai	1718922.363	279569.7537	14.7587
Guangdong	1873275.505	125217.6117	7.2846
Tianjin	2018898.175	-20404.0583	1.0892
Hubei	1889556.554	108938.5627	5.3959
Chongqing	2217615.433	-219119.315	11.5963354

The carbon emissions quota of the plant in 2014 calculated in the method of Tianjin and Chongqing is higher than that of the actual quotas. Maybe, the selection of the baseline values in Chongqing city are different from several other cities and the quota for adjustment is directly included in the existing capacity quota. The carbon emission is defined as the emissions of greenhouse gases to the atmosphere in Tianjin city, which could result in the deviation of the amount of the relative higher than the actual amount of the quota. The rate of deviation ranges small to large: Tianjin＜Guangdong＜Beijing＜Hubei＜Chongqing＜Shanghai. More detailed and accurate basis for the adjustment of the quota is provided in Tianjin, and the average carbon dioxide emission intensity of 2009 - 2012 is taken as the reference value. In Guangdong Province, the pure coal-fired generator group of the unit type and size are specified in detail for the conversed baseline values of the carbon dioxide emissions quota, which would make a good demonstration for improving the accuracy and precision of carbon quota accounting. The rate of the load factor is determined according to the performance of the power plant and the annual load rate in shanghai, but the detailed reference standards have yet been given.

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