E3S Web of Conferences **165**, 01029 (2020) https://doi.org/10.1051/e3sconf/202016501029
CAES 2020

CO_2 Emission Calculation and Emission Characteristics Analysis of Typical 600MW Coal-fired Thermal Power Unit

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Abstract. In order to effectively reduce the total CO_2 emissions of coal-fired power plants and reduce greenhouse gas emissions, the relevant data of a typical 600MW coal-fired power plant in the past five years was collected and investigated, and CO_2 emissions and emission intensity were calculated. And the results were used to measure the CO_2 emission level of coal-fired power plants. By comparing and analyzing the CO_2 emission intensity and emission trend of 600MW coal-fired units with different unit types and different fuel types, the CO_2 emission characteristics of typical 600MW coal-fired power plants are obtained.

1 Introduction

Greenhouse gases refer to any gases that absorb and release infrared radiation and exist in the atmosphere.In the *Kyoto Protocol*, six kinds of greenhouse gases are regulated and controlled: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCS), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6). According to the relevant research data of the *CDIAC (Carbon Dioxide Information Analysis Center)*, at present, the greenhouse gases emitted by China account for about all 29% of the world's largest emitter, and about 60% of the world's annual new greenhouse gas emissions come from China [1,2]. Affected by the energy structure, China's greenhouse gas emissions are mainly generated by the combustion of fossil energy, and coal-fired power generation enterprises are large fossil energy consumers. According to research, there are three main types of greenhouse gases produced by coal-fired power generation enterprises, mainly CO_2, CH_4, N_2O [3], CO_2 is the main one. According to relevant research, among the six greenhouse gases specified in the *Kyoto Protocol*, the temperature rise effect of CO_2 on the earth accounts for more than 50% [4]. Therefore, controlling the CO_2 emissions of coal-fired power plants can have a direct and positive impact on the reduction of greenhouse gas emissions in China. Due to the large distribution range of coal-fired power plants in China, the coal quality, unit type and capacity vary greatly. In order to more accurately and effectively control the CO_2 emissions of coal-fired power plants, this article has calculated the CO_2 emissions of different coal-fired power plants, and calculated emission characteristics were compared and analyzed.

2 Determination of calculation method

2.1. Method selection

In recent years, there are many methods for calculating the CO_2 emissions from coal-fired units. In this study, the basic method for compiling emission inventories of the power industry in the *Intergovernmental Panel on Climate Change (IPCC) Inventory Guide* was selected. This method includes three categories [5,6], Divided into the first method (T1), the second method (T2), and the third method (T3). Among these three types of methods, each type has its own characteristics and applicability. Among them, T3 is a detailed technology-based method. It divides power plant activity data according to different fuels and combustion technologies, and correctly distinguishes different fuel sources. Classification, detailed determination of the carbon content of different batches of fuel, reducing the uncertainty of the estimation results, better estimation of long-term trends [7], and more specific requirements on the type of coal combustion, industrial analysis of coal quality, and unit conditions, the more complete the requirements High, the accuracy of the calculated CO_2 emissions data is relatively higher. Therefore, this article adopts the T3 method, combined with the relevant contents in the "*Guidelines for the Calculation and Reporting of Greenhouse Gas Emissions of Chinese Power Generation Enterprises (Trial)*" (hereinafter referred to as the "*Guide*"), to measure and analyze the CO_2 emissions of coal-fired units.

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2.2 Research Scope

In this article, three coal-fired power plants of 600MW units in a certain region of China are taken as the research object to calculate the CO_2 emissions of the above-mentioned power plants in the last five consecutive years. Generally, the total CO_2 emissions of power generation enterprises include the emissions from fossil fuel combustion, desulfurization process and electricity purchase [8], and fossil fuel combustion accounts for 99% of the total CO_2 emissions [9], while the emissions from other processes only account for combustion About 1% of the total emissions of coal-fired power plants. Therefore, the calculation of CO_2 in this study includes three parts: emissions from fossil fuel combustion, emissions from desulfurization process and emissions from power purchase.

Table 1. Basic situation of 600MW power plants.

Power plants	Installed capacity	Unit type	Fuel type
Plant A	2×600 MW	Subcritica l units	Blended burning of bituminous coal and lignite
Plant B	2×600 MW	Supercriti cal unit	Blended burning of bituminous coal and lignite
Plant C	2×600 MW	Subcritica l units	Lignite

2.3 Calculation method

This article adopts the calculation formula for CO_2 emissions from fossil fuel combustion in the "*Guide*", and calculates the weight of dry-based carbon based on the moisture, ash, volatile matter, total sulfur, and heat generation data collected from the coal industry analysis data of each coal-fired power plant Content, by converting the dry base carbon to the received base carbon content, and then calculating the carbon content per unit calorific value, the coal-fired emission factor is calculated according to Formula 1.

Formula 1:

$$EF = CC \times OF \times \frac{44}{12} \tag{1}$$

In Formula 1, *EF* is the emission factor of coal combustion, the unit calorific carbon content of *CC* coal combustion, the carbon oxidation rate of *OF* coal combustion, and *44/12* is the ratio of the molecular weights of CO_2 and C.Calculate the activity level of coal burning according to Formula 2.

Formula 2:

$$AD = FC \times NCV \times 10^{-6} \tag{2}$$

In Formula 2, *AD* is the activity level of coal combustion, *FC* is the consumption of coal, and *NCV* is the average low heating value of coal combustion. Calculate the CO_2 emissions from coal combustion according to Formula 3.

Formula 3:

$$E = AD \times EF \tag{3}$$

In Formula 3, *E* is the CO_2 emissions from coal combustion, the activity level of *AD* coal combustion (in terms of calorific value), and *EF* is the emission factor for coal combustion.Calculate the CO_2 emissions per unit of coal consumption according to Formula 4.

Formula 4:

$$e = \frac{E}{FC} \tag{4}$$

In Formula 4, *e* is the CO_2 emission per unit of coal consumption, that is, the CO_2 emission intensity.

3 Analysis of emission characteristics

3.1. Overall emissions

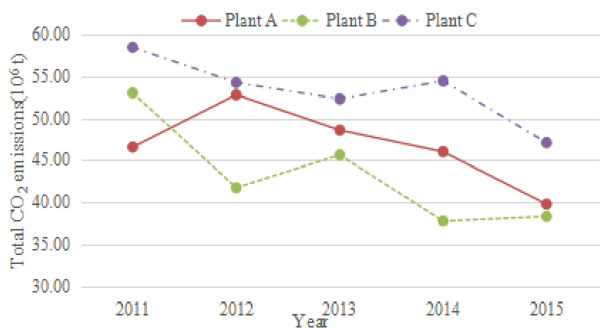

Fig. 1 Total CO_2 emissions of each power plant in the past 5 years.

Based on the moisture, ash, volatile matter, total sulfur, and calorific data collected from the coal-based industrial analysis data of each coal-fired power plant, the dry-based carbon content is weighted to calculate the content of the dry-based carbon. And then calculate the carbon content per unit calorific value, and finally calculate the total CO_2 emissions in the past 5 years. It can be seen from the figure that in the past five years, the total CO_2 emissions of various power plants have been reduced to varying degrees, and they have generally declined.

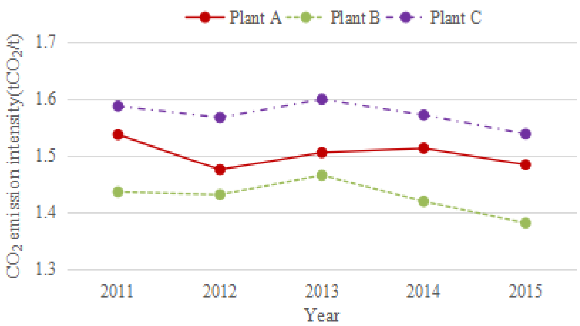

Fig. 2 CO_2 emission intensity of power plants in the past 5 years.

The CO_2 emissions per unit of coal consumption are further calculated to examine the CO_2 emission intensity of each power plant. As can be seen from Figure 2, the CO_2 emission intensity of each thermal power plant has changed in the past five years, but it has declined overall Trends, these are closely related to the country's emphasis on CO_2 emissions, power plant operation adjustments, technological transformation, energy saving and emission reduction and other means to reduce CO_2 emissions.

3.2. CO_2 emissions of different unit types

It can be seen from Table 1 that among the three power plants in the research scope, the fuel types of Plant A and Plant B in the past 5 years have been mixed with lignite and bituminous coal, and the unit types are subcritical units and supercritical units. Under the same conditions of the same type, the CO_2 emissions of different unit types in the past 5 years are compared, as shown in Figure 3.

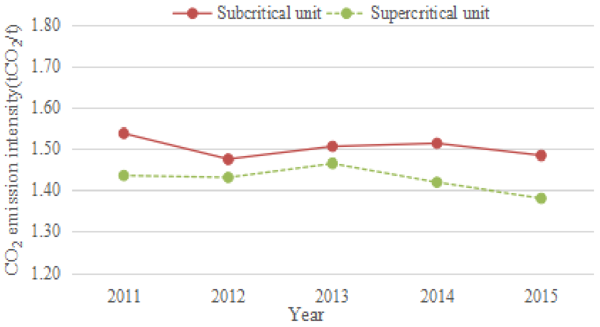

Fig. 3 CO_2 emissions of 600MW supercritical and subcritical units

It can be clearly seen from Figure 3 that in the past 5 years, the CO_2 emission intensity of a 600MW supercritical unit is significantly less than that of a 600MW subcritical unit, and the overall trend is declining. Due to the different characteristics of supercritical units and subcritical units, supercritical units have lower heat consumption and higher thermal efficiency than subcritical units. Compared with subcritical units, they can reduce heat consumption and save coal consumption Therefore, compared with subcritical units, supercritical units have lower heat consumption, high thermal efficiency, and low coal consumption, so that the amount of CO_2 produced by combustion is relatively low, and the CO_2 produced by unit coal consumption is lower. Therefore, the intensity of CO_2 emissions is lower than that of subcritical units.

3.3 CO_2 emissions of different coals

Among the three power plants under study, Plant A and Plant C are subcritical units. In the past 5 years, Plant A has adopted coal blending, Plant C has adopted lignite, and Plant C is a pithead power plant with stable coal sources. , Basically no change. Through calculation, it is found that the CO_2 produced by Plant C using lignite, which is a single coal type, is higher than that of Plant A, which uses lignite and bituminous coal.

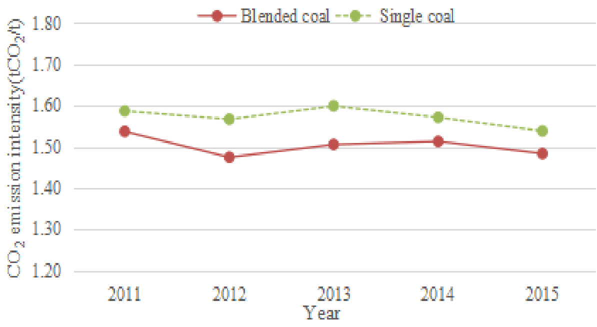

Fig. 4 CO_2 emission of different fuel type.

It can be seen from Figure 4 that the CO_2 emission intensity of brown coal-fired power plants in the past 5 years is higher than that of coal-fired power plants with bituminous coal and brown coal. From the perspective of the characteristics of the fuel, the carbon content of lignite and bituminous coal is different, and the calorific value of combustion is also different. Generally speaking, the calorific value of bituminous coal is higher than that of lignite, so the unit carbon content of bituminous coal and lignite is also different. . From the perspective of calculation, this study uses the T3 algorithm for calculation and analysis, and calculates the carbon content per unit calorific value of coal burning through data such as the coal quality test report of the power plant, and then calculates the total CO_2 emissions and emission intensity. During the calculation of this algorithm, The total amount of CO_2 emissions is greatly affected by the unit calorific value of carbon content of coal. The "*Guide*" gives the unit calorific value of carbon content of different fuel types, lignite is 27.97 tC/TJ, and bituminous coal is 26.18 tC/TJ, the calculated trend of CO_2 is the same as the trend of carbon content per unit calorific value. It can be seen that in the same type of 600MW units, the CO_2 emission intensity mainly depends on the carbon content per unit calorific value of the fuel. For the purposes of this study, the power plant has a higher CO_2 emission intensity than lignite and lignite coal .

4 Conclusion

In summary, by comparing and analyzing the CO_2 emissions per unit of coal consumption of coal combustion of 600MW coal-fired power plants of three different unit types and fuel modes, the following main conclusions are drawn:

1) Generally, the total CO_2 emissions and emission intensity of 600MW coal-fired power plants in five years showed a general downward trend;

2) CO_2 emission intensity of supercritical units of the same coal quality is lower than that of subcritical units;

3) In the case of the same type of unit, the CO_2 emission intensity of the unit with lignite and bitumite blended combustion is lower than the unit with lignite.

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