# Environmental Performance Evaluation of Thermal Power in China under GRI Standards

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**Keywords:** Environmental performance, GRI standards, coefficient of variation method, thermal power.

**Abstract:** In recent years, China's economy has entered a stage of rapid development, but the problem of ecological environment is increasingly serious. The causes of haze in most cities in China are the smoke, sulfur dioxide and nitrogen oxides emitted in the process of thermal power enterprises' production and operation. In order to ensure that the profits can maintain growth in an environmental-friendly way, thermal power enterprises must consider the impact of environmental performance in the process of production, operation and management supervision. According to the framework of the environmental performance evaluation system under the selected GRI standards, this article discusses the construction of the environmental performance evaluation index system of thermal power enterprises, and organizes five representative and comprehensive environmental performance evaluation indicators. In the term of evaluation method, this article adopts the coefficient of variation method to analyze and determine the specific weight of each index. At the same time, the environmental performance scores of enterprises are calculated by combining the normalization of data and the decimal method. We make a descriptive analysis of environmental performance scores and compare the scores of eight selected listed thermal power companies horizontally. Finally, this paper draws research conclusions and puts forward policy recommendations.

## 1. Introduction

In the 21st century, China is facing the problem of coexistence of economic development and environmental pressure. Behind the economic prosperity, there are relative environmental problems from time to time. Especially in recent years, the problem of environmental pollution in China has become relatively serious. With high PM2.5 detection value, the air quality in cities is far below expectation. Some cities suffer from long-term haze. As a result, many primary and secondary schools have to suspend classes. People need to take anti haze masks when they travel, which seriously affects the quality of life and happiness index of residents. One of the main causes of haze is China's thermal power generation.

As one of China's basic industries, thermal power generation creates value for China's economic benefits on one hand. On the other hand, it damages China's environmental benefits. In 2010, Chinese government extensively solicited opinions on the environmental information disclosure guidelines for listed companies, and finally classified 16 industries as high pollution industries on September 14 of the same year, namely, thermal power, electrolytic aluminum, coal, building materials, paper making, brewing, steel, cement, metallurgy, pharmaceutical, fermentation, textile, leather, mining, chemical and petrochemical industries. Concerned with the difficulty and workload of environmental pollution control, the thermal power industry is particularly prominent in 16 heavy pollution industries. In addition, according to existing data, China is the world's second largest economy and the world's largest energy consumer, with 20.3% of the world's energy consumption coming from it. The largest energy consumption of china is coal consumption, and among the coal consumption, thermal power consumption is the highest, accounting for more than 60% of the total coal demand of the country. At the same time, due to the sharp reduction of coal resources in China and the utilization of coal power that is far lower than the world's advanced level, it will only worsen the situation and pose a huge challenge to China's power industry. What's more, a large number of environmental pollutants generated by thermal power generation, such as smoke dust, sulfur dioxide, nitrogen oxides, etc., have caused terrible harm to human health.

Therefore, in the context of building a resource-saving and environment-friendly society, it is more meaningful to evaluate the environmental performance of thermal power production enterprises in the practical and theoretical value. This paper establishes the corresponding environmental performance evaluation system by studying the data of China's listed thermal power companies in 2013-2017. Based on the sustainable development report standard issued by the Global Reporting Initiative (GRI) in October 2016, this paper evaluates environmental performance of the thermal power industry in china, and recommends corresponding suggestions.

## 2. Evaluation Index System Based on GRI Framework

### 2.1 Introduction to GRI

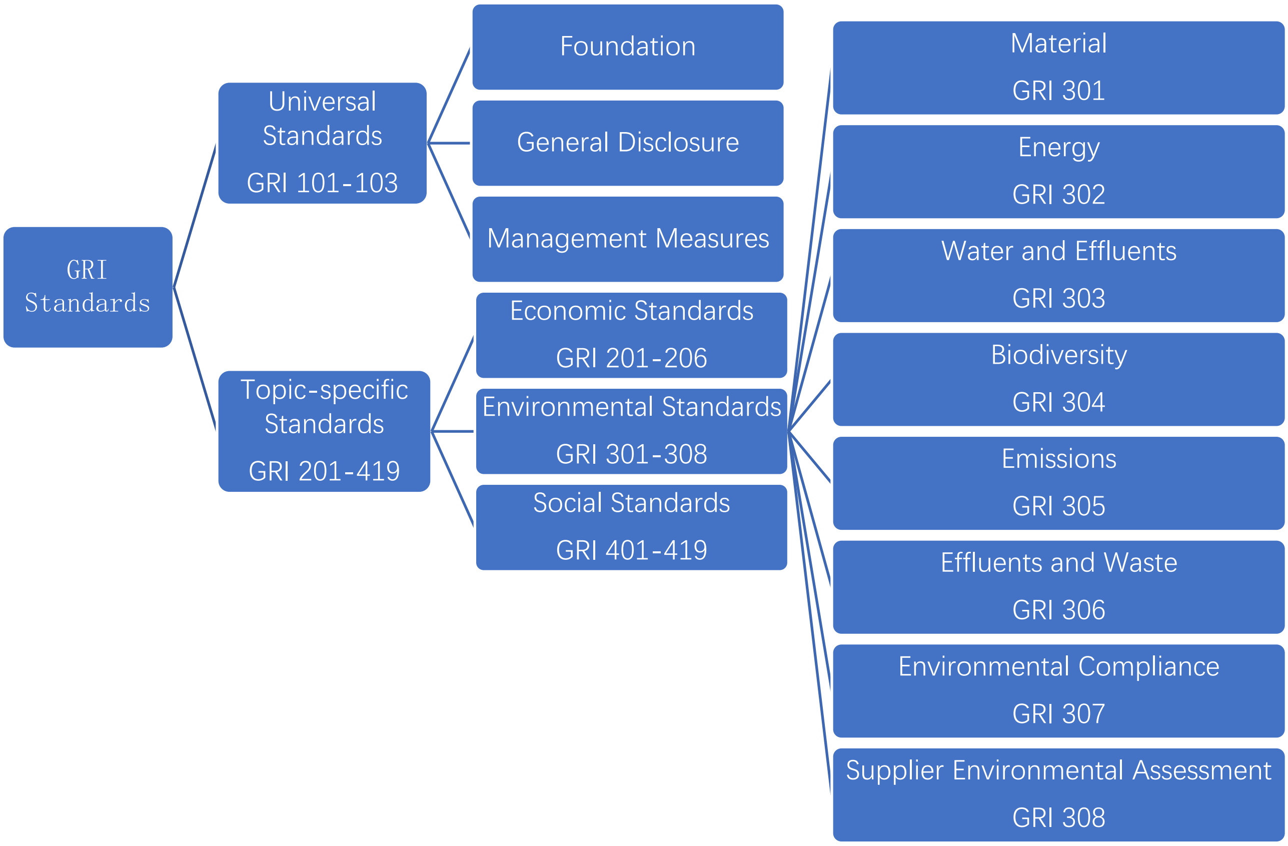


Fig. 1 GRI standards

In 1997, American NGOs, Coalition of Environmentally Responsible Economies (CERES) and United Nations Environment Program (UNEP) jointly launched an initiative to set up Global Reporting Initiative (GRI), whose mission is to prepare and promote the globally applicable guidelines for sustainable development reports. In 2000, GRI1.0, the first edition of the guide, which was also referred to as G1, was successfully written. The release of G1 further promoted the development of the organization. In September 2002, the organization established governance institutions including the stakeholder Committee and the technical advisory committee, and finally developed into an international independent organization, with its headquarters in Amsterdam, the Netherlands. In the same year, GRI2.0 (G2) was released successfully, and GRI organization began to grow. In 2006, the organization issued GRI3.0 (G3), which is further updated to GRI4.0 (G4) in 2013. In view of the standard confusion caused by the continuous revision and update of the guide, as well as the potential impact of multi stakeholders on the development process of the guide, Global

Sustainable Standards Board (GSSB) decided not to issue a new version of the guide again, but to develop a unified standard, and then refine, supplement and update it every year. Therefore, the sustainable development reporting standard (GRI standard) in 2016 replaced the G4 guide as a new generation of reporting standard.

Because GRI standards is generally the transition from G4 guide, it is also generally divided into Universal Standards and Topic-specific Standards. All enterprises are suitable for Universal Standards, while Topic-specific Standards can be selectively disclosed by enterprises according to the specific content of their business matters. The order of arrangement is shown in Fig. 1: (1) Universal Standards (GRI 101-103); (2) Topic-specific Standards (GRI 201-419): Economic Standards (GRI 201-206), Environmental Standards (GRI 301-308), Social Standards (GRI 401-419). Among them, Environmental Standards include: GRI 301 for Materials, GRI 302 for Energy, GRI 303 for Water and Effluents, GRI 304 for Biodiversity, GRI 305 for Emissions, GRI 306 for Effluents and Waste, GRI 307 for Environmental Compliance and GRI 308 for Supplier Environmental Assessment. This paper mainly uses indicators of Environmental Standards to evaluate the environmental performance of listed thermal power companies in China.

### 2.2 Evaluation Index System

Compared with other industries, the thermal power industry seems to be weak in environmental performance evaluation, and the relevant researches are in the preliminary stage. There are also many questionable places in the selection of evaluation indicators. The selection criteria of indicators in this study are: (1) indicators are disclosed by no less than 5 enterprises; (2) indicators belong to the Environmental Standards of GRI standard; (3) indicators are quantitative indicators rather than qualitative indicators; (4) indicators are all proportional indicators or ratio indicators to eliminate the impact of company size on environmental performance.

Table 1 Environmental performance index system of listed thermal power companies

| Indicator category | Indicator content | Indicator specific content | Unit |
|---|---|---|---|
| GRI 302 | Energy | Coal consumption of power supply | g/kWh |
| | | Service power consumption rate | % |
| | | Installed share of clean and renewable energy | % |
| GRI 305 | Emission | $SO_2$ emission performance | g/kWh |
| | | NOx emission performance | g/kWh |

Finally, five indicators are obtained, which can be divided into two categories: GRI 302 for Energy and GRI 305 for Emissions. In the energy index, the coal consumption of power supply comprehensively reflects the whole process of boiler, steam turbine generator, coal management and operation management of a thermal power plant, which is an important indicator of national energy saving adjustment. The service power consumption rate is a comprehensive energy saving index reflecting the production and transportation process of the power system. The installed share of clean and renewable energy reflects the attention of enterprises to clean and renewable energy, partly reflecting environmental indicators. The exhaust gas emissions from the production and operation of thermal power enterprises mainly include carbon monoxide, carbon dioxide, sulfur dioxide and nitrogen oxides. This paper selects two indicators, sulfur dioxide ($SO_2$) emission performance and nitrogen oxide (NOx) emission performance, which are more representative for evaluating the environmental performance of thermal power enterprises.

## 3. Evaluation Method

### 3.1 Coefficient of Variation Method

As an objective weighting method, the coefficient of variation method directly use the information in index data to determine the weights. This method calculates the coefficient of variation of the specific data set by the index. The bigger the coefficient of variation, the greater the weight of distribution. In the evaluation index system, the more difficult it is to achieve the index and the greater the difference of each sample data of the index value, the more able it is to reflect the gap between the evaluation indexes. That is the basic idea of the coefficient of variation method. In short, the greater the data difference of an indicator is, the more valuable the indicator is. Indicator without any difference is not necessary for research. Because there may be dimensional differences in each index, if the standard deviation is directly compared, it is easy to be affected by the degree of dimensional differences. Therefore, it is necessary to use the coefficient of variation of each index to measure the degree of difference in each index value.

Firstly, the coefficient of variation method only gives weight through the data itself rather than the subjective factors, avoiding the subjective imprecision. Secondly, through the coefficient of variation, i.e. the ratio of standard deviation and average value, we can avoid the influence caused by different dimensions. Last but not least, the calculation process is relatively simple, which can be obtained by further calculation in descriptive statistics. Therefore, this paper chooses the coefficient of variation method as the evaluation method.

### 3.2 Weight Determination

Since this paper studies the data of 2013-2017, the proportion of variation coefficient in each year is different, so the weight is calculated separately. In order to make each year comparable, the average weight is taken as the final weight data. The calculation steps of coefficient of variation method are as follows.

(1) This paragraph calculates the coefficient of variation of each index. See Table 2 for details.

Table 2 Coefficient of variation of each index

| Years | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|
| Coal consumption of power supply | 0.03 | 0.03 | 0.03 | 0.03 | 0.10 |
| Service power consumption rate | 0.18 | 0.21 | 0.23 | 0.25 | 0.39 |
| Installed share of clean and renewable energy | 0.40 | 0.38 | 0.34 | 0.32 | 0.33 |
| $SO_2$ emission performance | 0.79 | 0.89 | 0.91 | 0.75 | 0.43 |
| NOx emission performance | 0.57 | 0.79 | 0.85 | 0.78 | 0.31 |
| Total | 1.97 | 2.30 | 2.36 | 2.13 | 1.56 |

(2) This paragraph divides each coefficient of variation by the sum of the coefficients of variation to obtain the weights. See table 3 for details.

Table 3 Weights of each index

| Years | 2013 | 2014 | 2015 | 2016 | 2017 | Mean |
|---|---|---|---|---|---|---|
| Coal consumption of power supply | 0.02 | 0.01 | 0.01 | 0.01 | 0.06 | 0.02 |
| Service power consumption rate | 0.09 | 0.09 | 0.10 | 0.12 | 0.25 | 0.13 |
| Installed share of clean and renewable energy | 0.20 | 0.17 | 0.14 | 0.15 | 0.21 | 0.18 |
| $SO_2$ emission performance | 0.40 | 0.39 | 0.39 | 0.35 | 0.28 | 0.36 |
| NOx emission performance | 0.29 | 0.34 | 0.36 | 0.37 | 0.20 | 0.31 |

## 4. Environmental Performance Evaluation of Thermal Power

### 4.1 Sample Selection and Data Source

In this paper, the listed thermal power companies in China are taken as the research samples. And the sample companies are selected according to the following three principles: (1) the A-share listed companies in Shanghai Stock Exchange and Shenzhen Stock Exchange are taken as the primary samples; (2) in order to make the research results more accurate and reliable, we select the listed companies under normal operating conditions as the research samples; (3) because the level of environmental performance information disclosure of the listed companies in china is not high, we have eliminated the listed companies with incomplete data.☐

The sample data comes from the social responsibility reports of the sample company in 2013-2017. The environmental information data in the social responsibility reports is collected manually from the websites of Shanghai Stock Exchange, Shenzhen Stock Exchange and the official websites of listed companies. After elimination, 200 sample observations of 8 listed companies (Huaneng International, Guodian power, State Grid Power, China Datang, Hubei energy, China Guodian, Shanghai electric power, China Huadian) during 2013-2017 were finally obtained. Among them, the data of China Guodian in 2017 comes from State Energy Investment Group Co., Ltd that China Guodian and Shenhua Group have been merged and reorganized into.

### 4.2 Index Analysis

This paragraph makes preliminary statistics on the collected data, respectively describe and analyze 5 indicators of 8 enterprises. See table 4 to table 8 for details.

Table 4 Coal consumption of power supply (g/kWh)

| Years | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|
| Firms | 8 | 8 | 8 | 8 | 8 |
| Maximum | 320.27 | 316.12 | 313.28 | 313.85 | 307.90 |
| Minimum | 291.20 | 287.92 | 283.58 | 283.61 | 213.11 |
| Mean | 312.37 | 308.80 | 305.54 | 303.69 | 289.56 |
| SD | 8.58 | 8.27 | 8.96 | 8.72 | 29.78 |

As can be seen from table 4, the maximum and minimum values of coal consumption of power supply show a fluctuating downward trend, and the mean value shows a declining trend year by year, while the standard deviation shows a fluctuating upward trend.

Table 5 Service power consumption rate (%)

| Years | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|
| Firms | 8 | 8 | 8 | 8 | 8 |
| Maximum | 6.21 | 6.23 | 6.37 | 6.50 | 9.42 |
| Minimum | 3.24 | 2.72 | 2.55 | 2.55 | 2.65 |
| Mean | 4.96 | 4.71 | 4.53 | 4.61 | 5.18 |
| SD | 0.88 | 0.99 | 1.05 | 1.15 | 2.03 |

It can be seen from table 5 that in the service power consumption rate, the maximum value shows a fluctuating upward trend, while the minimum value shows a fluctuating downward trend. Meanwhile, the mean value shows a fluctuating upward trend, and the standard deviation shows a rising trend year by year.

Table 6 Installed share of clean and renewable energy (%)

| Years | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|
| Firms | 8 | 8 | 8 | 8 | 8 |
| Maximum | 64.34 | 66.28 | 64.95 | 63.99 | 68.05 |
| Minimum | 24.33 | 25.21 | 28.80 | 29.00 | 24.00 |
| Mean | 33.39 | 35.81 | 39.03 | 40.12 | 40.52 |
| SD | 13.44 | 13.73 | 13.45 | 12.88 | 13.56 |

As we can see from table 6, the maximum value of installed share of clean and renewable energy shows a fluctuating upward trend, while the minimum value and mean value show a rising trend year by year, but the minimum value falls back in 2017, and the standard deviation shows a fluctuating upward and downward trend.

Table 7 $SO_2$ emission performance (g/kWh)

| Years | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|
| Firms | 8 | 8 | 8 | 8 | 8 |
| Maximum | 2.00 | 1.80 | 1.42 | 0.72 | 0.21 |
| Minimum | 0.19 | 0.11 | 0.09 | 0.06 | 0.06 |
| Mean | 0.87 | 0.66 | 0.49 | 0.26 | 0.14 |
| SD | 0.68 | 0.58 | 0.45 | 0.20 | 0.06 |

From table 7, it can be seen that the maximum, minimum, mean and standard deviation of $SO_2$ emission performance are decreasing year by year.

Table 8 NOx emission performance (g/kWh)

| Years | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|
| Firms | 8 | 8 | 8 | 8 | 8 |
| Maximum | 2.60 | 2.00 | 1.42 | 0.84 | 0.27 |
| Minimum | 0.33 | 0.12 | 0.08 | 0.08 | 0.09 |
| Mean | 1.46 | 0.93 | 0.61 | 0.34 | 0.20 |
| SD | 0.83 | 0.74 | 0.52 | 0.27 | 0.06 |

What can be seen from table 8 is that the maximum, minimum, mean and standard deviation of NOx emission performance are decreasing year by year.

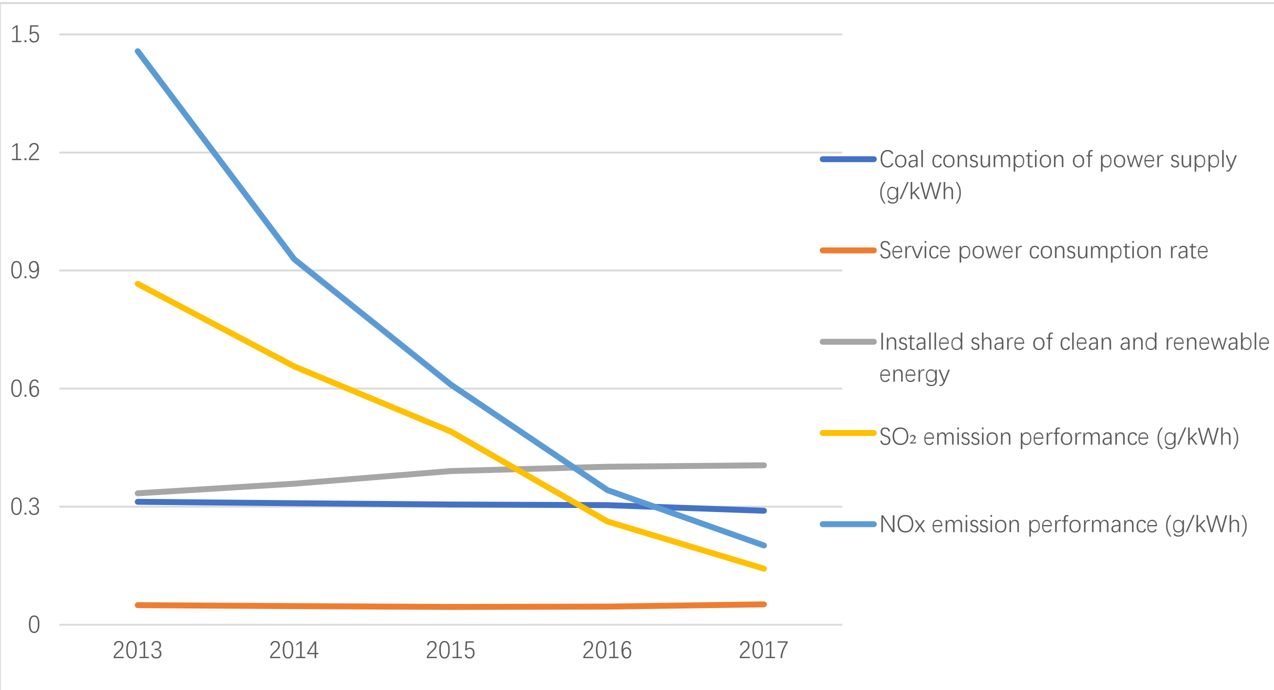


Fig. 2 Mean value of indicators

It can be seen from Fig. 2 that among the mean values of five index, $SO_2$ emission performance, NOx emission performance and coal consumption of power supply all show a downward trend, while the service power consumption rate declines first and then rise. Meanwhile, the installed share of clean and renewable energy shows an upward trend.

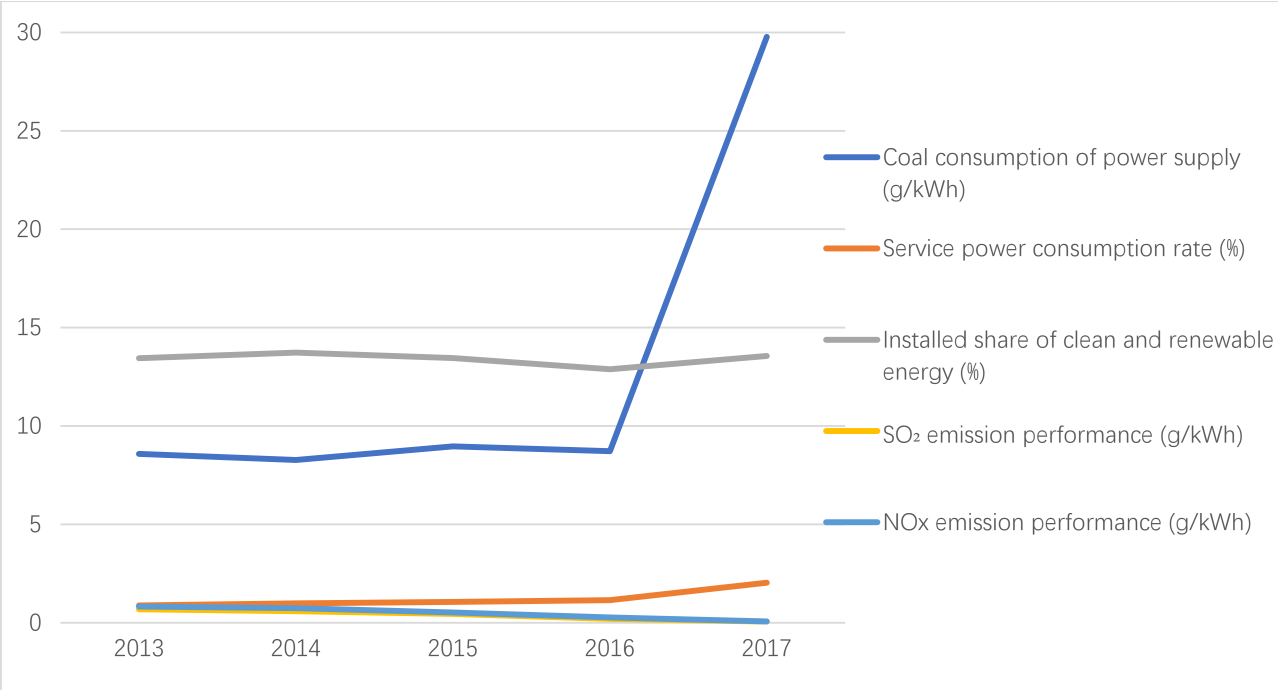


Fig. 3 Standard deviation of indicators

It can be seen from Fig. 3 that in the standard deviation of the five indicators, the coal consumption of power supply and service power consumption rate are on the rise, the $SO_2$ emission performance and NOx emission performance are on the decline, while the installed share of clean and renewable energy is stable.

### 4.3 Enterprise Analysis

The reverse index means that the higher the index value, the lower the level of enterprise environmental performance. While the same direction index is on the contrary. The indexes selected in this paper are all reverse indexes except the installed share of clean and renewable energy. It is necessary to carry out the same chemotaxis of the installed share of clean and renewable energy, whose index data is replaced with the value of 100%-X for the next calculation. In order to better show the average level and development trend of environmental performance of listed thermal power enterprises in China, this paper uses the decimal calibration standardization method to deal with the data dimensionless at first. Then it uses the coefficient of variation method to assign weights, and afterwards calculate the final environmental performance score.

Table 9 Descriptive analysis of environmental performance level

| Years | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|
| Firms | 8 | 8 | 8 | 8 | 8 |
| Maximum | 0.3500 | 0.3148 | 0.2747 | 0.2517 | 0.2605 |
| Minimum | 0.1614 | 0.1379 | 0.1186 | 0.1153 | 0.1249 |
| Mean | 0.2647 | 0.2332 | 0.2092 | 0.1918 | 0.1893 |
| SD | 0.0669 | 0.0613 | 0.0506 | 0.0384 | 0.0404 |

From Fig. 4, it can be seen that during 2013-2017, the mean value of environmental performance generally becomes smaller and smaller, which suggests that the average level of environmental performance of listed thermal power enterprises in China shows an increasing trend year by year. The standard deviation is slightly reduced, and slightly recovered in 2017, which shows that the difference of environmental performance between enterprises is steadily narrowing.

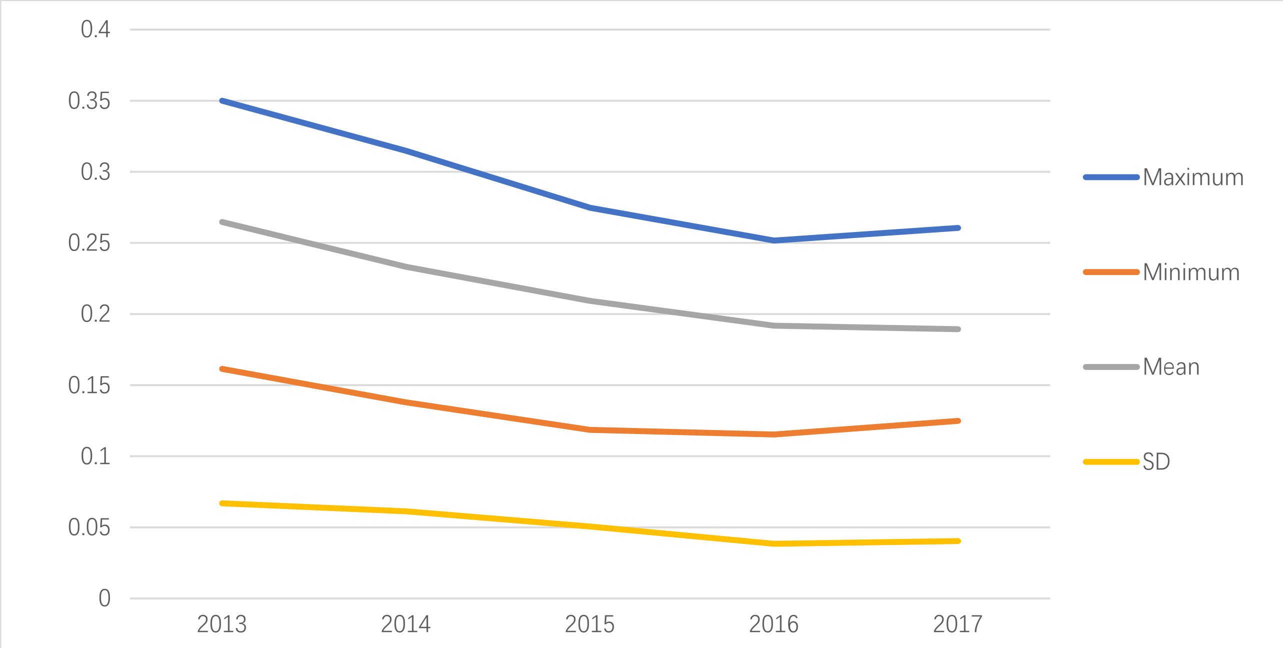


Fig. 4 Descriptive analysis of environmental performance level

Table 10 Scores of enterprise environmental performance

| Listed thermal power companies | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|
| Huaneng International | 0.2478 | 0.2180 | 0.2023 | 0.1972 | 0.1876 |
| Guodian power | 0.2451 | 0.2237 | 0.1910 | 0.1813 | 0.1727 |
| State Grid Power | 0.1614 | 0.1379 | 0.1186 | 0.1153 | 0.1249 |
| China Datang | 0.3480 | 0.3013 | 0.2637 | 0.2349 | 0.2605 |
| Hubei energy | 0.1953 | 0.1611 | 0.1670 | 0.1726 | 0.1598 |
| China Guodian | 0.3331 | 0.2950 | 0.2606 | 0.2517 | 0.2409 |
| Shanghai electric power | 0.2372 | 0.2136 | 0.1958 | 0.1879 | 0.1827 |
| China Huadian | 0.3500 | 0.3148 | 0.2747 | 0.1934 | 0.1854 |

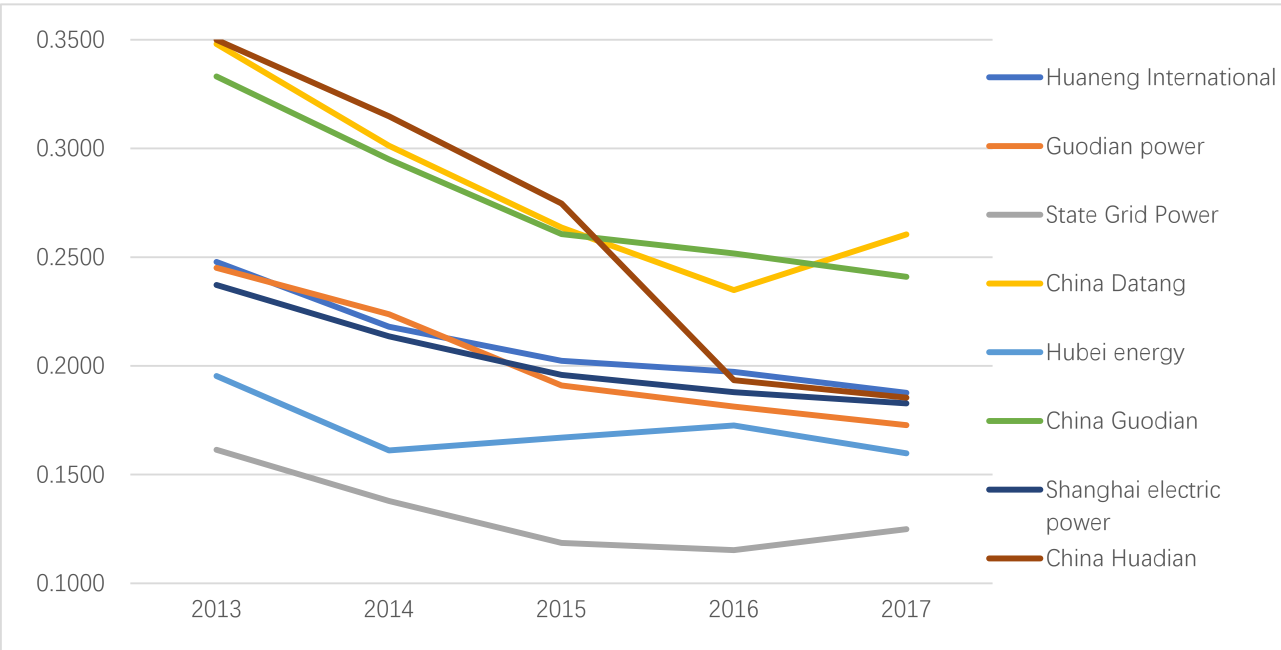


Fig. 5 Scores of enterprise environmental performance

From Fig. 5, it can be seen that during 2013-2017, the environmental performance indicators of Huaneng International, Guodian power, China Guodian, Shanghai electric power and China Huadian decreased year by year. While Guotou power and China Datang rebounded slightly in 2017, and Hubei energy increased in 2015 and 2016. This shows that the environmental performance level of most enterprises increased year by year from 2013 to 2017, and the environmental performance level of some enterprises fluctuated.

## 5. Conclusion

### 5.1 Environmental Accounting Information Disclosure Is Vague and Tends to Be Partly Disclosure

In the process of data collection, it is not difficult to find that the environmental accounting information disclosure in China is mainly in accordance with SGDs, ten principles, GRI standards, CASS-CSR4.0, etc. However, at present there is no unified standard and the level of environmental accounting information disclosure in listed thermal power companies in China is generally low. In this case, the standard of environmental accounting information disclosure is vague, the information disclosure is not regular but random, and tends to be partly disclosure.

Among the 53 listed thermal power companies, some of them did not publish their social responsibility reports on their official websites and their exchanges, such as Zheneng Electric Power. Most of them made vague and partly disclosure, describing their progress only in words, without data or example support, such as Guangdong Electric Power. The rest of them published positive data and the indicators given in previous years are different on their social responsibility reports, such as Hubei Energy. In terms of GRI framework, among the eight enterprises, only Huaneng International was listed in the index according to GRI standards in 2017's social responsibility report, while Shanghai Electric Power, China Guodian (National Energy), China Datang and China Huadian were listed according to G4, while Guodian Power, Guotou Power and Hubei Energy were not listed.

### 5.2 Overall Environmental Performance Shows an Upward Trend

Based on the analysis of the data of 8 listed thermal power companies in 2013-2017, the mean value of environmental performance indicators has decreased year by year, which shows that the overall environmental performance of listed thermal power companies in China is on the rise. Meanwhile, in these five years, the standard deviation of the overall environmental performance indicators is steadily decreasing, which shows that although the level of environmental performance of individual enterprises differs greatly, the gap is gradually narrowing. This is mainly due to the improvement of specific indicators: (1) the installed capacity of thermal power plant is developing towards large installed capacity, and the service power consumption rate is reduced, which is due to the good benefit of large units; (2) the emission performance of sulfur dioxide, nitrogen oxide and other exhaust gas of the representative sample thermal power enterprises selected in this paper is decreasing year by year; (3) the coal consumption of power supply reflects a comprehensive process of a thermal power enterprise in boiler, steam turbine generator, coal-fired management and operation management.

### 5.3 The Government Should Take Active Actions

Due to the special nature of the thermal power industry, which belongs to the heavy pollution industry, the government should strengthen the supervision of the environmental activities of enterprises, actively take actions to regulate the disclosure standards of thermal power enterprises, and timely supervise the waste discharge of thermal power enterprises, in order to prevent violations. Under the background of complying with the provisions of *the environmental protection law*, the local governments should also formulate some relevant laws and regulations according to their own characteristics, so as to make the most of *the environmental protection law*. The main measures are as follows.

(1) Formulate a unified disclosure format for social responsibility reports. According to the specific content of social responsibility report, combined with the particularity of environmental accounting information in thermal power industry, environmental accounting information reporting standards can be established. The report shall be disclosed annually and updated on the official website of the company and the exchange where the company's shares are located. Meanwhile, the specific indicators and data should be disclosed in the social responsibility reports. It would be better to establish a unified form or in a specific format. The appendix of the report should index the indicators in accordance with SDGs, ten principles, GRI standards, CASS-CSR4.0, etc., in order to prevent enterprises from selective or partly disclosure.

(2) Actively take good advantage of media supervision. As a third-party regulator, the media takes disclosing the truth as its own duty. The media workers and journalists with conscience and credibility tend to become a sword of supervision, and their credibility will further expand the influence of their disclosure content in the public. At the same time, as individuals, media workers are not eye-catching. It is difficult to prevent them as the hidden regulators, which can effectively deter the improper behavior of enterprises. The implementation of environmental laws and regulations, supplemented by media supervision, can effectively alleviate information asymmetry and improve the efficiency of regulatory action.

(3) Strengthen the supervision of small enterprises. In order to be representative, the empirical research of this paper selects the large-scale and deeply influential listed companies. Although most of Chinese thermal power enterprises are state-owned holding companies with large scale, there are still small-scale thermal power enterprises, whose environmental performance is far less than that of the enterprises studied in this paper. And the situation is not optimistic. Therefore, when the government supervises the environmental accounting information of thermal power enterprises, it should also strengthen the supervision of small-scale enterprises.

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