IOP Conf. Series: Earth and Environmental Science **128** (2018) 012171 doi:10.1088/1755-1315/128/1/012171

Energy saving and consumption reducing evaluation of thermal power plant

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Abstract: At present, energy saving and consumption reduction require energy saving and consumption reduction measures for thermal power plant, establishing an evaluation system for energy conservation and consumption reduction is instructive for the whole energy saving work of thermal power plant. By analysing the existing evaluation system of energy conservation and consumption reduction, this paper points out that in addition to the technical indicators of power plant, market activities should also be introduced in the evaluation of energy saving and consumption reduction in power plant. Ttherefore, a new evaluation index of energy saving and consumption reduction is set up and the example power plant is calculated in this paper. Rresults show that after introducing the new evaluation index of energy saving and consumption reduction, the energy saving effect of the power plant can be judged more comprehensively, so as to better guide the work of energy saving and consumption reduction in power plant.

1. Introduction

In recent years, the energy industry has focused on energy issues and high efficiency and energy saving. China's per capita energy share is much lower than the world average, the per capita coal occupation is about 50% of the world's per capita coal occupation, the oil share is 10% of the world average, and natural gas is only about 20% of the world's per capita share. [1] At the same time, China still has many problems, such as low utilization efficiency, serious environmental pollution, irrational energy structure and so on. It has greatly restricted the development of our economy.

At present, China's energy structure is mainly coal, and it will be difficult to change in the future. The coal consumption of the national thermal power generation units is far more than half of the total coal output. [2]. However, there is a big gap between the energy consumption level of China's thermal power plant and the world advanced level, which makes the energy consumption of thermal power plant higher and the pollution heavier. And, from the second half of 2016, coal price began to stop a year of fall, a strong rebound. On the one hand, the coal price is running at a high level for a long time. On the other hand, the policy direction of "cost reduction" makes the final electricity price difficult to adjust, and the two sides of coal and electricity can only slowly push forward the supply side reform through continuous gaming. Because of the big difference in the degree of marketization of the two industries of coal and electricity in China, the coal market and electricity use plan, the contradiction between coal and electricity cannot be completely resolved for a long time. Because of the national policies, measures for energy saving and consumption reduction in thermal power plant will play a very important role in China's economic development and the progress of the power industry. How to evaluate the energy saving status of thermal power plant accurately, it is necessary to establish a reasonable energy consumption evaluation system, which has important guiding significance for energy saving and consumption reduction in thermal power plant.

2. Energy saving and consumption reduction evaluation system

Energy saving evaluation system of thermal power plant refers to the administrative department of electric power collection power plant internal experts and technical staff establishing the relevant management system and work on the basis of experience and the actual situation of national and industry related standards. [3] As shown in Figure 1, the energy saving evaluation system of thermal power plant mainly includes three aspects: energy consumption index, energy saving index and energy saving management index. [4] The main content of energy saving work is to save coal, electricity, water, oil and so on, and these contents are concentrated on the big index of power supply coal consumption. The evaluation index system of energy saving is to decompose various factors that affect the power consumption of coal into small indicators of boiler, small indicators of steam turbine and small fuel index. Through analysing the influencing factors, we can find out the reasons for the increase or decrease of coal consumption, so as to take corresponding measures.

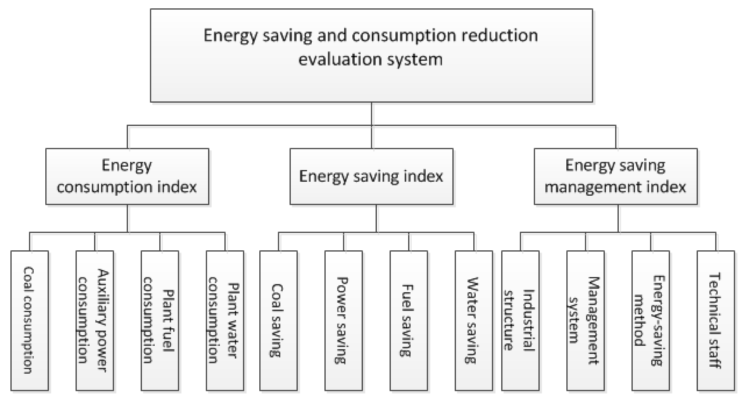

Figure 1. Main indexes of energy saving system

The key to establish energy-saving system is to select the correct and effective energy saving evaluation index. However, in the process of thermal power plant production, the indicators that can reflect energy saving and consumption reduction are not single, and there is an interrelated relationship between them [5].

For the power plant, the evaluation criteria are different, so the evaluation method of the index is different. The index system can be divided into the core index system (quantitative evaluation index method) and extended index system (qualitative evaluation index method) [6]. In the above evaluation index system of energy saving and consumption reduction, the energy saving management index is a qualitative evaluation index. The qualitative index does not evaluate the benchmark value, which is relatively subjective.

The threshold method is used to deal with the index, and the revised Delphi method is used to evaluate the weights of the indexes. On this basis, a comprehensive evaluation model is constructed to classify the energy conversion degree in the group system, and vertical and horizontal comparisons are made to provide information for energy saving decision-making.

3. Evaluation index of energy saving and consumption reduction production

The production and operation of a power plant, from the point of view of energy utilization, is the process of converting chemical energy into thermal energy and mechanical energy, and finally to electrical energy. The production process satisfies the law of thermodynamics, so the energy conversion efficiency of thermal power plant is less than 1[7]. From the angle of capital operation, it is the process of getting the expected income after investment, which satisfies the economic principle, so its capital operation efficiency must be more than 1.

As the main raw material of thermal power plant, fuel cost is the largest variable cost of thermal power plant power generation cost. Under normal circumstances, the fuel cost of thermal power plant accounts for 60% of the total cost of the power plant [8]. As fuel prices surged from the end of last year, at present, about 65% of the total cost of fuel cost stations.

Therefore, this paper puts forward the evaluation index E_2, which contains the essential content of the production and operation activities and the basic formula is defined as follows:

$$E_2 = P/I \tag{1}$$

In (1) , P represents the power output of thermal power plant; I represent the input of power generation in thermal power plant. For the pure condensing unit, the output P can be calculated by the price of electricity and the correction factor:

$$P = k * p_e \tag{2}$$

In (2), k is the correction factor of the starting mode, k can load rate and power generation completion rate of the product obtained (is that the amendment significance must have the correct boot mode, such as power generation but an increase of load rate fell way should be avoided.); p_e is the price of electricity for fire power plant. The input quantity I can be calculated by the lower form:

$$I = m * p_m \tag{3}$$

In (3), p_m is for converting the standard coal unit price, converting the standard coal unit price is 70% of the standard coal unit price, m is the power supply coal consumption of the thermal power plant. The coal consumption of the power supply can be decomposed as follows.

$$m = \frac{\eta_q}{29.271 * \eta_l * \eta_g * (1 - L_{cy})} \tag{4}$$

In , η_q is turbine heat consumption rate, η_l is the boiler efficiency and η_g is th pipeline efficiency.

$$P = k * (p_e + p_{re}) \tag{5}$$

For the heating unit, according to the basic formula, the heating correction is carried out in the electricity price. It is defined as:

$$p_{re} = (P_r * p_r) / P_e \tag{6}$$

p_{re} is a unit price for heating, which can be calculated by heating supply.

In (6), p_r stands for heating capacity in thermal power plant; p_r means heating price; P_e represents the power supply of a thermal power plant.

In thermal power plant projects, we must go through a rigorous calculation, that is, the internal rate of return of capital is greater than 8%, that is to say, the selected evaluation index E_2 must be qualified when it is greater than 1.66. After strict classification, the index of E_2 is ascertained as follows:

Table 1 Grading of evaluation indices

Evaluating indicator	E_2
Good	>1.66
Pass	1.66
poor	<1.66

4. Example of energy saving and consumption reduction evaluation

Considering that there are many factors that affect the evaluation of energy conservation and consumption in thermal power plant, this paper mainly considers the overall situation of energy saving technology measures and the general situation of power plant operation, that is, parameter and power consumption coal consumption parameters and parameters E_2, and evaluates the energy consumption and actual operation of power plant. The first level of evaluation system is 2 evaluation indexes, which are coal consumption and E_2. The second level of evaluation system is 4 first level quantitative evaluation index, including boiler index, turbine index, power consumption rate index and operation index. The third level of the evaluation system is a number of two grade evaluation indexes corresponding to the first level quantitative evaluation index. Power consumption and production and operation indexes of power plant A in 2016 are as follows:

Table 2 Operation indexes of power plant A in 2016

time	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average
Coal consumption（t）	130548	118788	87739	114847	97971	108528	115739	131270	102928	107422	125390	137552	
Power supply（k.kWh）	172948	161189	124705	181363	153178	167468	174741	176411	142835	144703	164973	178489	
Heat supply (GJ)	326783	278316	180456	56640	0	0	0	105789	88974	172614	276914	320255	
E_2	1.8	1.87	1.89	1.62	1.89	1.91	1.88	1.83	1.37	0.91	0.96	0.94	1.45
Power supply coal consumption（g/kWh）	245	256.99	253.11	283.9	313.34	313.78	317.04	323.77	324.15	292.88	249.65	238.34	275.81

Power consumption and production and operation indexes of power plant B in 2016 are as follows:

Table 3 Operation indexes of power plant B in 2016

time	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average
Coal consumption（t）	148514	122122	170774	178881	156314	152594	137537	183780	244615	191749	178696	191762	
Power supply（k.kWh）	332602	205779	298376	309757	277067	263153	241156	315553	426588	341775	315854	332602	
Heat supply (GJ)	245434	212902	164907	73479	0	0	0	0	0	88492	196970	235432	
E_2	2.75	2.18	2.14	1.76	2.14	2.13	2.19	2.2	1.6	1.05	1.16	1.14	1.7
Power supply coal consumption（g/kWh）	354.33	348.56	347.69	348.66	351.99	352.78	353.33	350.8	349.92	346.61	346.23	341.44	349.11

Power consumption and production and operation indexes of power plant C in 2016 are as follows:

Table 4 Operation indexes of power plant C in 2016

time	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average
Coal consumption（t）	278146	229144	192095	127782	137584	134136	161269	178744	156737	225091	254327	323416	

Power supply (k.kWh)	555837	460062	360644	236320	242178	238607	280058	309028	275635	408749	498478	610217	
Heat supply (GJ)	996936	713904	484314	174326	0	0	0	0	0	301214	723118	917734	
E_2	2.7	2.72	2.47	1.99	2.13	2.2	2.17	2.21	1.61	1.15	1.39	1.33	1.85
Power supply coal consumption (g/kWh)	295.8	296.81	306.89	311.73	319.96	327.11	325.99	325.89	325.16	312.67	286.04	306.85	308.26

A two-dimensional coordinate system is established for the three plants. The two-dimensional coordinate system is established by taking power supply coal consumption as the abscissa and E_2 as the vertical coordinate. The evaluation results can be used as a standard for horizontal comparison between power plant and for the analysis of internal problems in power plant. That is factory A, B, C, it can be seen that although A power plant consumption is relatively low, the operation effect is the worst. Although the power plant coal consumption of power plant is relatively high, but the other cost is well controlled, the overall income level is higher than that of power plant A. The operation of the power plant C is the best.

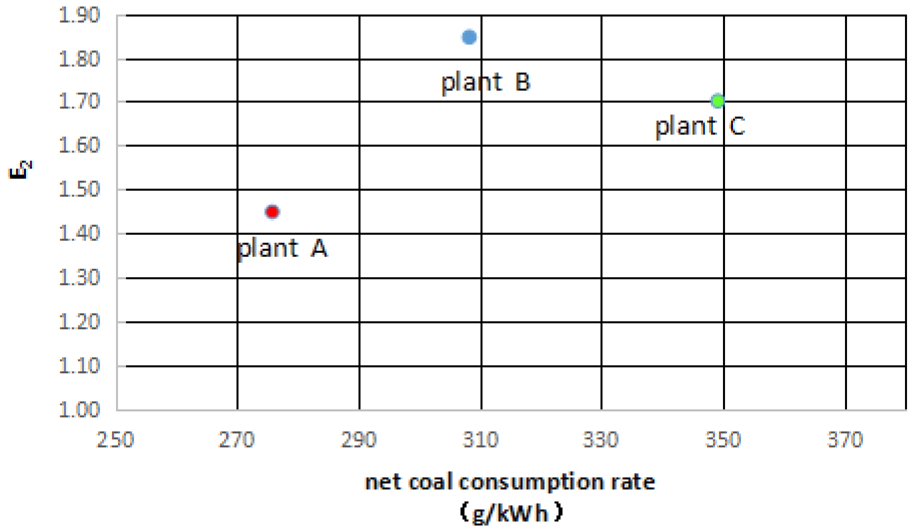

Figure 2 2D coordinate system

From the above, we can see that the operation of the power plant combines technology and management indicators. For the power plant's technical indicators, we should not pay much attention to strengthening management in other areas, and business indicators are not necessarily good. Therefore, the energy conservation and reduction work of power plant should consider the energy conservation and emission reduction of the unit, and strengthen management, fundamentally reduce investment and improve the economic efficiency of the enterprise.

The fluctuations in the production of small indicators directly affect the unit fuel cost, which can be controlled through production management. By controlling the technical and economic indicators and controlling the coal consumption, the production department can control and reduce the unit fuel cost to a certain extent. In the current economic management of the power plant, the economic objectives of the management department of production and fuel are entirely consistent. The production department ensures the quality of the equipment and maintains the economic operation. The factors that affect the unit fuel cost will be eliminated as much as possible. Otherwise, the unit fuel cost is directly affected. Therefore, to improve economic performance and improve economic indicators, we must do everything in terms of strengthening equipment improvement, improving maintenance quality, improving operation management and improving economic operation.

5. Conclusions

With the energy crisis and environmental pollution issues becoming increasingly prominent, energy saving and emission reduction actions are particularly important. As a large energy consuming country in China, thermal power plant take measures to save energy and reduce consumption, not only can alleviate the crisis, reduce pollution, but also promote the economic development of enterprises. The establishment of energy-saving and consumption reduction evaluation system of thermal power plant will enterprises to evaluate the operation of thermal power plant and take effective actions. The establishment of a scientific evaluation system of energy saving and consumption reduction should follow the principles of comprehensiveness, scientific, systematisms, importance, feasibility and operability, and adopt a reasonable evaluation system and research methods.

Because there are many evaluation factors of energy saving, it is necessary to establish a framework of energy saving and consumption reduction evaluation system and determine the quantitative evaluation criteria of energy saving indicators. This paper puts forward the evaluation index of contains the production and business activities of the content, the standard for evaluation of the weight, the accurate evaluation of the thermal power plant energy saving, energy saving so as to establish a scientific evaluation system. This will play an important role in improving the economic benefits of enterprises, reducing environmental pollution, and realizing the sustainable development strategy of our country.

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