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Analysis of the Situation of the Coal Procurement and the Optimization of the Procurement Plan in Thermal Power Enterprises

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Abstract

In typical thermal power enterprises, the proportion of fired coal holds the weight of about 70% of its variable cost. In this sense, for power plants, a successful cost control of the fired coal is equivalent to controlling the profit index of power plants. At the same time, there are many grades of coal, the quality of coal has a great impact on the power generation efficiency of thermal power units. Therefore, the coal procured by thermal power enterprises must be able to satisfy a number of quality evaluation indexes in order to meet the needs of power production. In this paper, a mixed integer planning model is constructed for coal procurement plan, and a two-stage simplex method is designed to solve the problem. By taking an electric power enterprise as a study case for the empirical analysis, the results of which show that the model and algorithm can significantly reduce the coal procurement cost of the thermal power enterprise.

Keywords

coal procurement, procurement plan, thermal power enterprises.

1. Introduction

Coal procurement of thermal power enterprises refers to the procurement of a certain variety and quantity of coal at a proper price in a proper period from a proper coal supplier on the premise of ensuring the quality of coal in order to meet the needs of power generation [1, 2]. The coal procurement management of thermal power enterprises involves all the management activities taken in the whole process [3], which is the basis and prerequisite for the organization of the power production in thermal power enterprises. Profit is taken by Chinese thermal power enterprises as the most important standard to measure their benefits. Based on the existing operational activities of thermal power enterprises in China, and if the impact of the internal non-electric sector of the enterprises is not considered, the key to determine the profits of thermal power enterprises is the difference between the price and the cost of electricity. Generally speaking, the indicators applied to reflect the operation status of thermal power plants mainly include: power-generating capacity, electricity sold to the grid, coal consumption for power supply, unit price of standard coal for power supply, unit fuel cost, on-grid electricity price, fixed cost and total profit, etc. The operating benefits of thermal power enterprises can be fully reflected by the use of these indicators [4, 5].

2. Characteristics of Coal Procurement in Thermal Power Enterprises

(1)Coal procurement in highly organized and planned manner

When procuring coal, thermal power enterprises decide their procurement policy according to the factors such as their annual and monthly production plan, coal consumption, market supply and demand of coal, and capital capacity. In terms of the mode of procurement, the forms taken should be as flexible and diverse as as possible, such as signing coal procurement contracts with coal suppliers at the coal ordering conference or choosing the best in quality and the cheapest in price in the coal market, which requires the procurement department of the thermal power enterprise to organize and coordinate in a careful manner with the reflection of a strong planning.

(2)Certain preparation time needed for coal procurement

In general, the coal procurement of thermal power enterprises involves large quantity. In some thermal power enterprises, the annual procurement of coal can reach up to 100 million tons; The coal consumption of thermal power industry in 2012 reached 4.36 billion tons. Coal is the main energy source in China. However, the coal resources are concentrated in the western and northern regions of the country, especially in Shanxi, Shaanxi and the western part of Inner Mongolia, while the economically developed areas in China with large demand for energy are mainly distributed in the eastern and southern coastal areas. Therefore, coal supply, no matter in terms of procurement, transportation or storage, needs a certain amount of time to prepare. Whether the procurement is planned or unplanned market action, it is necessary to work out a correct coal procurement plan on the basis of investigation and research, and make a correct decision based on the variety, specification, quantity, price, delivery time, supplier and service of coal. In the process of procurement, it often needs to go through many times of negotiation and negotiation, until the power and coal parties reach an agreement or sign a contract to officially determine the procurement. The content of the contract to be signed must be considered in a careful and comprehensive fashion in accordance with the relevant provisions of the economic contract law, aiming to avoid unnecessary contradictions or disputes in the process of implementation.

(3)Prescribed procedures to be strictly followed during the purchasing process

In general, the coal procurement of thermal power enterprises has to go through certain management levels. the procedures must be respected for coal procurement application, check & approval, and selection of supply point to specific procurement. All this must be strictly followed. The purpose is to prevent management confusion and to avoid unnecessary losses.

(4)Complexity of the variety of coal and the rigid quality requirements

The main types of coal used in power generation of thermal power enterprises are anthracite, lean coal, anthracite, injection coal, gas coal, power coal, lignite, etc. The quality of coal for power generation is determined by various indexes of the variety, such as calorific value, moisture, volatile matter, sulfur, and especially calorific value. The quality of coal has a significant impact on the power generation efficiency of the thermal power enterprise. Therefore, the coal procured by thermal power enterprises must be able to satisfy multiple quality evaluation indexes to meet the needs of power production.

(5)Coal purchasers required to have rich professional knowledge

Due to the complexity of fire coal varieties and strict quality requirements, the procurement personnel of thermal power enterprises must possess rich professional technical knowledge and a certain amount of economic management knowledge in the whole process ranging from the selection to the procurement of coal, to ensure the efficient and normal operation of the whole procurement process.

3. Optimization Method of Coal Procurement Plan for Thermal Power Enterprises

From the point of view of the characteristics and the process of fire coal procurement, it is very important to make a scientific and reasonable fire coal procurement plan. In the same business environment, the quality of the coal procurement plan directly determines the cost of fire coal power plant. In the fire coal power generation enterprises, the task of preparing the coal procurement plan is to determine the quantity of various quality coal procured from different suppliers. The coal procurement plan should be able to achieve two basic goals: guaranteed supply and increase of efficiency. Guaranteed supply aims to ensure production demand, including quality and quantity; efficiency is to reduce procurement costs and improve the economic efficiency. Therefore, the preparation of coal procurement plan is the critical key to ensure the normal production and to improve the economic benefits of the enterprise.

In order to maintain the stability of the coal supply chain, the enterprise must procure from multiple suppliers. Each supplier will choose different means of transportation depending on its geographical location and logistics channels, mainly including the transportation by railway, by ship or by truck, or by mixed transportation modes. Figure 1 shows the coal procurement structure of a thermal power plant in multi-supplier environment. Different suppliers have different price, quality and other indicators, so different procurement plans will lead to different coal procurement prices and coal quality. In this paper, based on the characteristics of fire coal demand of thermal power enterprises, and combined with the practical problems encountered in fire coal procurement of thermal power enterprises, the optimization model of fire coal procurement plan is established to achieve the procurement of sufficient and high-quality coal at the lowest cost. It is of great significance in terms of both theory and practice to guide the procurement department to ensure a scientific, reasonable, economic and effective procurement plan by establishing a fire coal procurement optimization model suitable for the actual production of thermal power enterprises.

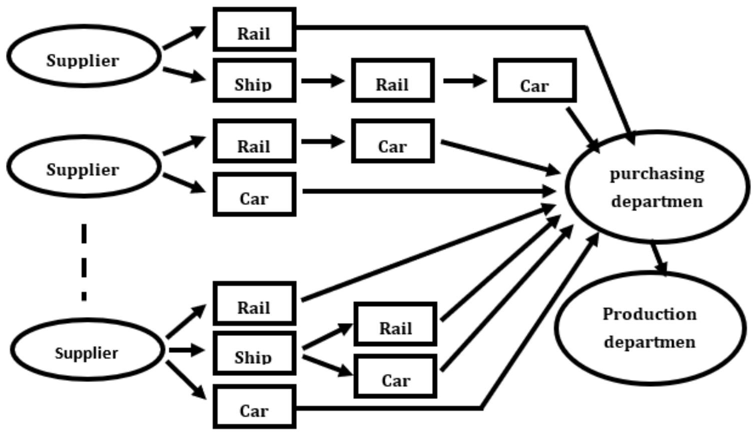

Figure 1. structure of coal procurement in thermal power enterprises in a multi supplier context

Some assumptions and boundary conditions need to be set before the optimization model of coal procurement plan is established. Here the thermal power enterprise is assumed to have multiple power plants with multiple suppliers. Each power plant submits their coal demand plan on a monthly basis, the content of which includes the coal demand itself and the quality related requirements. There are many indexes available for determination of the coal quality, such as calorific value, volatile matter, sulfur content, moisture, ash, etc. Yet in the actual production of power plants, only calorific value, volatile matter and sulfur are typically considered. Therefore, this model only considers three coal quality indexes, namely calorific value, volatile matter and sulfur content (the coal quality indexes selected in this model can be either increased or decreased at will).

The coal quantity (i.e. weight) demand and the coal quality requirement of each power plant are assumed as known factors. The maximum supply of each supplier is also known, and

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similarly, the quality of coal provided by each supplier as well as the procurement price of each power plant from different suppliers is also known. In this model, the actual incoming raw coal price is used as the coal procurement price. The actual incoming raw coal price can be calculated by the factory price, vehicle on-board price, freight-related miscellaneous charges, road loss, incoming coal calorific value and the expected calorific value difference. Sometimes, the supplier's delivery volume is an integral multiple of a fixed value. For example, when the supplier delivers the coal by railway, it can only deliver the goods on the basis of a whole carriage or a whole train; and when the supplier delivers goods by ship, there are ships of different tonnage available.

The objective of the optimization model of coal procurement plan is to minimize the total procurement cost on the premise of meeting the minimum coal quantity and quality demand of the power plant, without exceeding the maximum supply capacity of the supplier nor less than the minimum dispatchable lot of the corresponding logistics channel.

Constraints of the optimization model of coal procurement plan. In order to ensure that the procurement plan meet all production requirements as well as the actual conditions, the specific constraints are set as follows:

1)The total quantity of coal procured by each power plant from all suppliers shall not be less than the planned procurement quantity of the power plant;

2)The total amount of coal procured by each power plant from all suppliers shall not exceed the planned procurement funds of the power plant;

3)The total quantity of coal provided by each supplier for all power plants shall not exceed the maximum supply capacity of the supplier and shall not be less than the minimum dispatchable quantity of corresponding logistics channels;

4)The average calorific value of coal procured by each power plant shall not be lower than that of the required average;

5)The average volatile content of coal procured by each power plant shall not be lower than that of the required average;

6)The average sulfur content of coal procured by each power plant shall not be higher than that of the required average.

4. Effect Analysis of Coal Procurement Plan Optimization Method Applied in the Given Thermal Power Enterprise

In order to understand the effect of the optimization method of coal procurement plan in a more intuitive way, we take the actual production data of the given thermal power enterprise as an example to demonstrate, with the demonstration results being analyzed by comparison.

The given power Co., Ltd. (hereinafter referred to as "the company") has four thermal power plants. The company formulates monthly budget indicators such as coal procurement volume and heat value of entering the plant. Each power plant reports its own coal procurement plan under the guidance of the company's budget indicators. Finally, the company entrusts a third-party fuel company to procure according to the procurement plan. The company has always used the method of manual compilation to prepare the procurement plan, and manually adjust the procurement quantity to identify a group of procurement plans that meet the budget indicators. Then the procurement plan will be finally submitted to the relevant leaders for approval. In the process, the procurement plan may be slightly adjusted.

We use the company's procurement plan data in the first four months of a year for empirical research to compare the advantages and disadvantages between the optimized procurement plan and the original one. The input data of the optimization model is based on the original procurement plan, in which the planned procurement quantity and incoming coal quality requirements of the original plan are the constraint boundaries of the optimization data, that is, to ensure that the optimized procurement quantity is not less than the original planned procurement quantity and the optimized incoming coal quality is not less than the original planned incoming coal quality. Since there is no inventory data of the suppliers, the maximum supply capacity of suppliers is 10% increased on the basis of the original procurement plan, instead. For example, if Power Plant 1 procures 30000 tons of coal from Supplier 1 in the original procurement plan, the maximum supply of Supplier 1 in the optimization model is 33000 tons.

Moreover, in order to meet the demand of coal ordering, to ensure the needs during the peak winter and Spring Festival, the power generation company has ordered a large quantity of imported coal in advance. Therefore, in the optimization calculation, all imported coal quantities are set at the same quantity as that stated on the original procurement plan.

Because the relevant data belongs to the confidential category of enterprises, the empirical study only discloses the data of total quantity of the coal procurement, the average coal quality and the total procurement funds in each month's procurement plan. See table 1-4 for the data comparison of the procurement plans in each month.

Table 1. Comparison of optimized results of coal procurement plan in January

Index		Unit	Power plant 1	Power plant 2	Power plant 3	Power plant 4	Total
Original purchase plan	Planned coal volume	Ten thousand tons	36.30	38.00	30.30	15.00	119.60
	Calorific value	Kcal / kg	5111.83	5124.77	5036.77	3931.69	4948.92
	Volatile	%	26.69	24.88	23.60	11.12	23.38
	Sulfur content	%	1.24	1.30	1.20	0.90	1.20
	Planned capital	Ten thousand yuan	25036.15	26024.58	20858.39	6797.78	78716.90
Optimized plan	Planned coal volume	Ten thousand tons	36.30	38.00	30.30	15.00	119.60
	Calorific value	Kcal / kg	5111.83	5124.77	5036.77	3931.69	4948.92
	Volatile	%	26.93	24.88	23.60	11.12	23.46
	Sulfur content	%	1.20	1.30	1.19	0.81	1.18
	Planned capital	Ten thousand yuan	24836.19	25901.36	20747.32	6708.66	78193.53

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Table 2. Comparison of optimized results of coal procurement plan in February

Index		Unit	Power plant 1	Power plant 2	Power plant 3	Power plant 4	Total
Original purchase plan	Planned coal volume	Ten thousand tons	21.20	24.50	21.90	10.20	77.80
	Calorific value	Kcal / kg	5106.33	5067.83	5078.23	3965.11	4936.68
	Volatile	%	26.58	22.89	23.42	11.21	22.52
	Sulfur content	%	1.30	1.39	1.11	0.99	1.23
	Planned capital	Ten thousand yuan	13767.02	16274.15	14731.52	4636.43	49409.12
Optimized plan	Planned coal volume	Ten thousand tons	21.20	24.50	21.90	10.20	77.80
	Calorific value	Kcal / kg	5106.34	5067.85	5078.26	3965.15	4936.69
	Volatile	%	26.92	22.89	23.42	11.21	22.61
	Sulfur content	%	1.30	1.39	1.10	0.99	1.23
	Planned capital	Ten thousand yuan	13678.61	16265.29	14711.00	4593.92	49248.81

Table 3. Comparison of optimized results of coal procurement plan in March

Index		Unit	Power plant 1	Power plant 2	Power plant 3	Power plant 4	Total
Original purchase plan	Planned coal volume	Ten thousand tons	25.40	23.80	21.90	14.60	85.70
	Calorific value	Kcal / kg	5164.06	5233.51	4872.71	3820.83	4875.14
	Volatile	%	25.91	26.41	23.50	9.80	22.63
	Sulfur content	%	1.19	0.97	1.02	1.10	1.07
	Planned capital	Ten thousand yuan	15323.27	15857.31	13103.81	6191.43	50475.82
Optimized plan	Planned coal volume	Ten thousand tons	25.42	23.81	21.91	15.00	86.14
	Calorific value	Kcal / kg	5165.41	5234.27	4873.12	3820.97	4875.98
	Volatile	%	26.61	26.85	23.67	9.80	23.00
	Sulfur content	%	1.16	0.93	1.01	1.04	1.04
	Planned capital	Ten thousand yuan	15263.94	15815.89	12983.44	6310.15	50373.42

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Table 4. Comparison of optimized results of coal procurement plan in April

Index		Unit	Power plant 1	Power plant 2	Power plant 3	Power plant 4	Total
Original purchase plan	Planned coal volume	Ten thousand tons	22.50	22.00	17.30	17.00	78.80
	Calorific value	Kcal / kg	5267.49	5219.68	4761.87	4081.21	4887.20
	Volatile	%	27.21	26.86	23.70	13.27	23.34
	Sulfur content	%	0.97	1.02	1.03	0.96	1.00
	Planned capital	Ten thousand yuan	13981.15	14280.65	9895.25	7849.83	46006.88
Optimized plan	Planned coal volume	Ten thousand tons	22.50	22.00	17.30	17.00	78.80
	Calorific value	Kcal / kg	5267.49	5219.64	4761.88	4081.22	4887.21
	Volatile	%	27.46	27.22	23.98	13.27	23.57
	Sulfur content	%	0.96	1.01	1.03	0.95	0.99
	Planned capital	Ten thousand yuan	13940.84	14219.50	9880.18	7831.50	45872.02

For the convenience of the comparison, the total procurement funds of each month's procurement plan and the optimized procurement plan are displayed in one single table, as shown in Table 5.

Table 5. Comparison of total coal procurement funds before and after optimization

Month	Total procurement fund	Total optimized procurement funds	Saved funds	Proportion of saving funds
	Ten thousand yuan	Ten thousand yuan	Ten thousand yuan	%
January	78716.90	78193.53	523.37	0.66
February	49409.12	49248.81	160.31	0.32
March	50475.82	50373.42	102.40	0.20
April	46006.88	45872.02	134.86	0.29
Mean Value	56152.18	55921.95	230.24	0.41

It can be observed from Table 5 that the procurement funds in each month have been reduced, with about RMB 27.628 million yuan of the annual average coal procurement funds being saved.

5. Conclusion

Reducing the cost of fire coal procurement is one of the important ways for thermal power enterprises to improve their economic benefits and reduce the operating costs. Development of a fire coal procurement plan in a scientific and reasonable sense is the key to reduce the cost of fire coal procurement. The empirical study of the given power company shows that the optimization method of coal procurement plan designed in this paper can effectively reduce the cost of coal procurement. It is worth noting that although the optimization method of coal procurement plan is able to save a considerable amount of the procurement funds for the given power limited company, the proportion of procurement funds saved is not large, and the average saving proportion is only 0.41%. However, bearing in mind the huge capital base of coal procurement of the given power limited company, it can bring in considerable economic benefits. This may be due to the facts that the price difference of coal with the same quality is relatively small, and the change range of the coal price and quality is roughly in a synchronized pattern.

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