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Market Analysis of Natural Gas for District Heating in China

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Abstract

Natural gas (NG) is expected to be used broadly in China to replace coal in district heating sector in order to reduce air pollution due to coal burning. However, it is difficult for natural gas to penetrate district heating market due to its relatively high cost. In the present study, a market simulation method is proposed to find the marginal conditions and policy to promote natural gas utilization for district heating. In the proposed method, technology improvement, pricing mechanism, carbon tax and user's pricing response are considered. The prerequisite of the market simulation is that the heating expenses of end-users won't increase and the benefit of heat producers won't decrease when using NG to replace coal. Based on the obtained analysis results, gas pricing revolution, heating pricing revolution and carbon tax mechanism are discussed in order to promote the gas-fired heating through market mechanism.

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Keywords: gas-fired district heating; market analysis; pricing mechanism; carbon tax

1. Background

For a long time, coal has been supporting Chinese rapid economic development as a key source of energy. However, inefficient coal burning has caused serious air pollution in China, which pushes China to pursue clean energy. Under this circumstance, natural gas (NG) is gradually becoming the new focus because of its significant advantages in environmental protection and efficiency. In the past decade, China has been working on increasing NG supplies mainly through two channels: domestic production, and NG import. The domestic production from both the conventional gas resources (including onshore and offshore), and other unconventional resources such as coal-bed methane and shale gas is increasing steadily, in addition, NG import has been increased through pipeline and liquefied NG (LNG). When the gas supply is ensured, it's essential to stimulate gas consumption in order to promote the further development of NG industry. one way is to increase gas application to district heating system.

In district heating system, coal is the dominant fuel China. However, due to the severe air pollution caused by coal utilization, more NG is expected to be utilized considering its less negative impacts. But it's not easy to popularize gas-fired heating system because of its higher operation cost and the double-track pricing system for gas-fired heating and coal-fired heating. Based on this background, a market simulation model is proposed to find the marginal conditions for natural gas to replace coal in district heating sector base on the technology development and market policy which can fill the cost gap between gas-fired heating and coal-fired heating and motivate the heating market to use more gas instead of coal.

2. Model description

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To evaluate the economy of the coal-fired heating system and gas-fired heating system under different conditions, the proposed market simulation model integrates the need from heat producers, end-users and government consideration. In order to achieve the goal of maximizing the profit, heat producers can freely choose coal or gas as fuel to produce heat. As more pollution is caused by coal-fired heat production than by gas-fired heating production, the Government would impose. It is further assumed that the heat metering-based pricing mechanism is applied, and there is one single heat price whether the fuel is gas or coal. Then, the production costs of heat based on coal and NG can be calculated as:

$$C_{heat-c} = C_{heat-cf} + Q_{haat-c} \times P_c + T \quad (1)$$

$$C_{heat-g} = C_{heat-gf} + Q_{heat-g} \times P_g \quad (2)$$

Where C_{heat-c} and C_{heat-g} is the cost of 1 MJ heat produced by coal-fired and gas-fired boiler, $C_{heat-cf}$ and $C_{heat-gf}$ is the fixed cost of 1 MJ heat, Q_{haat-c} and Q_{heat-g} is the quantity of coal and gas producing 1 MJ heat, P_c and P_g is the coal and gas price, T is carbon tax of 1 MJ heat.

To get the reasonable results, the model is subject to the following constraints:

1. To promote the utilization of NG, the profit of using NG should be higher than using coal after introducing the carbon tax.

$$C_{heat-g} < C_{heat-c} \quad (3)$$

2. Profit of heat producer shouldn't be negative.

$$P_{heat} - C_{heat-c} > 0 \quad (4)$$

$$P_{heat} - C_{heat-g} > 0 \quad (5)$$

Where P_{heat} is heat price after the heat price reform.

3. Heating expenses of end-users shouldn't be increased when shifting the fuel from coal to NG.

3. Data analysis

Taking the Beijing market as an example, the Thermal efficiency of coal-fired boilers is generally between 70% - 80%, while the one of gas boilers can reach 90%. On average, the investment costs of coal-fired boilers and gas-fired boilers are 1.3 million RMB/ MW and 0.47 million RMB / MW respectively. Assume that boilers only run in the heating season which amounts to 120 days and their service life are 10 years. Currently in Beijing, industrial pipeline NG price is 3.23 RMB/m^3, and standard coal price is about 720 RMB/ton. The cost comparison of coal-fired heating and gas-fired heating are listed as follows:

Table 1. The comparison on cost between coal-fired heating and gas-fired heating.

	Coal-fired heating	Gas-fired heating
Fuel price	0.72 RMB/kg	3.23 RMB/m^3
Fuel price in RMB/MJ	0.0381 RMB/MJ	0.0831 RMB/MJ
Fuel heat value	18.9 MJ/kg	38.87 MJ/m^3
Average boiler efficiency	75%	90%
boiler cost	130 million RMB/MW	47 million RMB/MW

Based on the cost information shown in Table 1, Eq. 6 and 7 can be rewritten as:

$$C_{heat-c} = \frac{0.72 \times 1MJ}{(18.9MJ \times 75\%)} + T \times 1MJ + \frac{1300000}{10 \times 120 \times 24 \times 3600} \times \frac{1MJ}{1MW} = 0.0633 + T \ (RMB) \quad (6)$$

$$C_{heat-g} = \frac{3.23 \times 1MJ}{(38.87MJ \times 90\%)} + \frac{470000}{10 \times 120 \times 24 \times 3600} \times \frac{1MJ}{1MW} = 0.0968 \ (RMB) \quad (7)$$

In order use more gas instead of coal, profit of gas-fired heat producer should be higher than coal-fired heat producer, which can be expressed as Eq. 8.

$$C_{heat-c} - C_{heat-g} > 0 \quad (8)$$