Research on Natural Gas Price Mechanism Based on Pipeline Gas Pressure

Zhuofu Xie

ABSTRACT

A use of pipeline gas pressure forming gas market price method, using the main gas supply and demand changes affect network of gas pressure (or the number of moles of gas per unit volume) found that the gas market price, including the main gas supply business (gas) and gas network interface automatic sensor installation, main gathering network nearby gas pressure value or the number of moles of the gas per unit volume; Use a formula to form the gas price coefficient of the overall market; Use formula to form the gas price of the local market; Use formula to form the gas price of the overall market; This paper solves the problem of how to realize gas marketization, especially provides a set of detailed solutions for the marketization of pipeline natural gas in China, which has obvious social and economic benefits.
1. THE PRESENT SITUATION OF NATURAL GAS PRICE FORMATION MECHANISM IN CHINA

The historical evolution of natural gas price formation mechanism in China can be divided into three stages: highly centralized government pricing period, double-track pricing period and government-guided pricing period[1-3].

(1) The government pricing (1949-1982)

After the founding of the People's Republic of China until April 1982, China implemented a highly centralized planning system for natural gas prices, which were uniformly priced by the state, and production enterprises had no independent pricing power.

(2) Price double track system (1982-2005)

From May, 1982 to December, 2005, was the period of China's dual-track natural gas pricing system, namely the implementation of planned monopoly pricing and market pricing of natural gas two different pricing mechanism.

(3) Government guided price (Since 2005 -)[4-5]

In order to straighten out the price of natural gas, promote the conservation of gas use and ensure the supply of natural gas in the domestic market, in December 2005, the national development and reform commission introduced relevant policies and measures to reform the formation mechanism of ex-factory price of natural gas and uniformly implement the government-guided price of natural gas. Since the implementation of the government-guided price of natural gas in December 2005, the state has been strengthening the reform of natural gas price. Until April 2015, the price of existing gas and incremental gas has been integrated, and the price of direct supply natural gas station has been lifted on a pilot basis.

| Prime period | Government-guided prices | Price double track system | Government guided price |
|--------------|--------------------------|---------------------------|------------------------|
| 1949-1982    | The government sets the price uniformly, carries out the plan monopoly pricing, the enterprise does not have the pricing power | 1982-2005 | Cost plus, market net return value, provincial gate station price, etc |

TABLE I. China's natural gas pricing mechanism.
It can be seen from the above table that the evolution direction of China's natural pricing mechanism is from government monopoly pricing to full marketization. In order to avoid runaway market prices, the dual-track pricing system and government-guided pricing are only intermediate evolution forms, and the final result is definitely full marketization pricing.

To some extent, the import price of LNG in northeast Asia reflects the supply and demand of China's natural gas market. According to the above figure, the price changes have increased, but the price in China's natural gas market has not changed, which indicates that the price mechanism has great deficiencies and room for improvement.

To sum up, China's natural gas price mechanism is still in the exploration stage, during which it has experienced such price generation mechanisms as cost-plus pricing method and market net return value pricing method. At present, the marketization process of pipeline gas price and LNG price is slow, and the price formation mechanism that fully reflects the change of supply and demand of natural gas market has not been found. By constructing a pricing mechanism based on pipeline gas pressure, this paper uses pipeline gas pressure to reflect the characteristics of market supply and demand, and forms a relatively objective marketized price, so as to promote the process of China's natural gas marketization reform.
2. GAS PRICES ARE BASED ON PIPELINE PRESSURE

2.1 Gas Equation of State

The equation of gas state, also known as the ideal gas law, describes the relationship between temperature, volume, mass, and pressure when an ideal gas is in equilibrium. The equation is

\[ P_1 = \frac{nRT}{V} \]  

Among them: \( P_1 \) is the pressure of an ideal gas, \( V \) is the volume of an ideal gas, \( n \) is the number of gaseous substances, and \( T \) is the thermodynamic temperature of an ideal gas. \( R \) is the ideal gas constant.

According to this equation, when the temperature and volume of natural gas remain unchanged and in equilibrium, the pressure is proportional to the mass.

\[ P_1 = k_1 \times N \]  

Among them: \( P_1 \) is the pressure of natural gas, \( N \) is the quantity of natural gas, and \( k_1 \) is the pressure coefficient of natural gas.

2.2 Pressure Balance and Supply and Demand Balance Price

When natural gas is in the balance of supply and demand, the system of supply and demand of natural gas is at the pressure equilibrium point, which can reflect the balance between supply and demand in the market. Therefore, under the condition of constant temperature and vessel (pipeline) volume, the change of pressure of pipeline supply and demand point can reflect the change of market resource scarcity degree to a large extent, and further reflect the change of market supply and demand balance price.

\[ P = k \times P_1 \]  

Among them:

\( P \) is the market price of natural gas, \( P_1 \) is the pressure of natural gas, and \( k \) is the price coefficient of natural gas.
2.3 Ideal Market Model of Natural Gas Supply and Demand

This paper constructs an ideal natural gas market model. Market participants include gas supplier, gas user and pipeline operator. The balance change of gas supply and gas consumption is reflected by the change of pipeline pressure, that is, the market price is formed by pipeline pressure. The gas supplier settles the income through the gas supply pressure, the gas user settles the cost through the gas pressure, and the pipeline operator gains the income through the pressure difference between the gas supply point and the gas use point.

Each natural gas supplier connects to the main pipe network through the pipeline and automatically measures the flow rate and pressure of the pipe network through electronic instruments at the interface. In this way, a small local gas market will be formed at each junction, and the whole ring network will form a large regional gas market. The main participants in the market trade are gas suppliers, pipe network operators and gas users. They trade in accordance with the market trading rules and the prices automatically formed at the interface. They trade in real time, pay in real time and settle accounts in real time.

The electronic instrument for automatic air pressure measurement at the interface between the main natural gas pipe network and the gas supplier and the gas supplier is the market price generating device. The basic principle is that the measured pressure $P$ (or the number of moles of methane per unit volume) for a given period of time multiplied by the price formation factor $\alpha$ equals the price of natural gas for that period of time in the market. Namely:

$$\pi_t = \alpha_t \times P_t$$

(4)

$\pi_t$ is the price of natural gas in time period $t$ of market; $\alpha_t$ is the price formation coefficient of the whole pipe network system in time period $t$. The price formation coefficient of the first year and the second year is preliminarily determined by the natural gas industry alliance according to the market development situation and based on the principle of sustainable development. $P_t$ is the pressure of market I at time $t$ (or the number of moles of methane per unit volume), which changes in real time as the market trades.

The price of the entire network is calculated by the following formula:

$$\pi_t = \frac{\sum_{i=1}^{n} \pi_{ti} \times m_{ti}}{\sum_{i=1}^{n} m_{ti}}$$

(5)

$\pi_t$ is the market price of natural gas in the whole pipeline system, $n$ is the number of connections in the main pipeline network of the whole system, and $\pi_{ti}$
is the price of natural gas in the market i in time period t; \( m_{it} \) represents the volume of natural gas traded in the market i at time t (Calorific value of natural gas).

The price formation coefficient of the whole pipe network is calculated by the following formula:

\[
\alpha_{t+1} = \frac{\alpha}{n} \sum_{i=1}^{n} \frac{\pi_{ti}}{P_{ti}} + \frac{(1-\alpha)}{n} \sum_{i=1}^{n} \frac{\pi_{(t-1)i}}{P_{(t-1)i}} 
\]  

(6)

Where \( \alpha_{t+1} \) is the price formation coefficient in time period t+1, \( n \) is the number of local small markets contained in the overall market, \( \alpha \) is the smoothing coefficient, and its value range is (0~1).

The price formation coefficient of pipe network is calculated repeatedly, and the influence of the price formation coefficient formulated by the early industry association is gradually reduced, and the influence of market supply and demand factors is gradually increased.

3. PARTICIPANT PRICING

3.1 Pricing Method of Gas Supplier

The payment of gas supplier j in time period t is calculated by the following formula:

\[
Q_{jt} = \pi_{tj} \times m_{jit} 
\]  

(7)

\( Q_{jt} \) is the payment of gas supplier j in time period t, \( \pi_{tj} \) is the price of natural gas in time period t, and \( m_{jit} \) is the volume of natural gas traded between gas supplier j and gas supplier i at time t (calculated by calorific value).

3.2 Pricing Method of Gas Consumers

The payment for goods with gas quotient i in time period t is calculated by the following formula:

\[
Y_{it} = \pi_{tti} \times m_{jit} 
\]  

(8)

Where, \( Y_{it} \) is the payment of gas quotient j in time period t of market i, \( \pi_{tti} \) is the price of natural gas in time period t of market i, and \( m_{jit} \) is the volume of natural gas traded between gas quotient j in time period t and gas quotient i (calculated by calorific value).
3.3 Pricing Method of Pipeline Conveying Party

The price formation of the natural gas pipeline network operator is calculated by the following formula:

\[ L_t = Y_t - Q_t \]  

(9)

Where, \( L_t \) is the revenue of pipe network operators in time period \( t \), \( Y_t \) is the price of all gas suppliers in the system in time period \( t \), and \( Q_t \) is the price of all gas suppliers in the system in time period \( t \).

3.4 Revenue From Natural Gas Pipeline Operators

When gas users and suppliers do not trade in the same market, that is, the gas they trade needs to be transported through the gas pipeline. Suppose that the gas supplier is in the market \( J \) and the gas supplier is in the market \( I \). The revenue of network operators is calculated by the following formula:

\[ L_{tij} = Y_{ti} - Q_{tj} = \pi_{ti} \cdot m_{jit} - \pi_{tj} \cdot m_{jit} = (\alpha_t \cdot P_{ti} - \alpha_t \cdot P_{tj}) \cdot m_{jit} \]

(10)

That is, the network operator's income is in direct proportion to the pressure difference of the weather, in direct proportion to the natural gas network price formation coefficient, and in direct proportion to the heat of the natural gas transported, and has nothing to do with other factors.

4. CONCLUSIONS AND SUGGESTIONS

4.1 Conclusions

In conclusion, based on the technical invention, the market trading system based on gas pipeline pressure (or mole number of gas per unit volume) can realize such functions as trading according to market rules, "gas-to-gas" competition, automatic balance between market supply and demand, automatic peak adjustment of pipe network and automatic balance of the whole system.
4.2 Suggestions

(1) It is suggested that the state should formulate different natural gas price policies according to local conditions and different places;
(2) Carry out pilot projects to use pipeline gas pressure to form market price for air sources and places where it is not easy to form a monopoly;
(3) Promote the use of pipeline gas pressure to form the market price plan in the case of gaining sufficient experience in the pilot;

REFERENCE

1. Engineering; Researchers' Work from North China Electric Power University Focuses on Engineering (Pricing Mechanism for Natural Gas Distributed Generation Based On Classified Benchmark Price). Energy Weekly News, 2019.
2. Xiucheng Dong. 2019. “Construction of China natural gas trading center and price formation mechanism,” Economic and trade observation of new energy, Z1):28-29.
3. Guotong Wu, Yanxi Li. 2018. “Research on natural gas pricing mechanism,” China engineering consulting, 08:57-60.
4. Peibei Mao. 2018. “Analysis of natural gas price formation mechanism in China,” Modern marketing (current issue), 09:15-16.
5. Zhiguo Xie. 2008. “Promoting natural gas futures trading to accelerate the marketization process of the industry,” International petroleum economy, 26(06):5-9.