Analysis of Energy Supply Chain in Steel Industry
Self-provided Power Plant

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Abstract. Based on the requirements of low carbon emissions, and aiming at the practical problems of unreasonable utilization of residual by-product gas and gas emission in iron and steel complex, the energy supply chain in iron and steel complex is preliminarily discussed and analysed from the perspective of system engineering. The main problems existing in energy supply chain in iron and steel complex are put forward from four aspects: raw material supply, node connection, management and environment. It lays a theoretical foundation for further research on the optimal scheduling of energy supply chain network.

Keywords. Iron and steel complex, Self-provided power plants, Energy supply chain Residual by-product gas.

1. Introduction
In recent years, a large of surplus gas is in China's iron and steel complex. They will cause gas diffusion or insufficient, because of the irregularity and continuity of gas in production and consumption. At present, the gas of average emission rate of Chinese iron and steel complexes is as high as 5.76%, while the gas of average emission rate of advanced countries in the world is only 1%. The difference is very obvious, only this one difference causes our country's energy consumption per ton of steels to increase 5% [1-3]. From this point of view, it's the first issue how to use these surplus gas resources, and reduce complex energy consumption and create the greatest economic, environmental and social benefits. At present, there are many ways to utilize the surplus gas. Among them, the most commonly used method of gas recycling is power generation. The unreasonable utilization of residual by-product gas is the main factor that restricts the economic development, the main reason is the unreasonable dispatching mechanism and lack of scientific operation consciousness. Now, many domestic and foreign scholars have researched on this. They mainly focus on the following two aspects: one is the technological innovation and energy regulation related of the gas system; the other is the optimization of the gas system.

Fu Bing researched that the research and development of gas recovery turbine for power generation is an effective way to reuse by-product gas [4]. Chen Zhibin etc. researched that utility model adopts a gasification cooling flue to recover a large amount of steam, which can be used for heating, dining hall,
bathing and other facilities [5]. Stark R. J researched that the United States Armco Steel Branch established an energy management system, the system can coordinate the company's energy distribution, control the total cost of energy, then achieve the measurement of energy consumption and energy distribution [6]. India has also made some progress in establishing an energy centre for Steel Industry, Ramani B. researched that BHILAI steel of India integrates energy monitoring and energy modelling into a unified energy management system. In 2013, Li Hongjuan etc. researched that the frequent fluctuation of residual by-product gas in iron and steel complexes had a serious impact on the energy consumption and gas balance of self-provided power plants, and the established mechanism model was difficult to forecast [7-8].

The literature on gas system is mainly focused on technology innovation, energy regulation and optimal scheduling [9-11]. It's lack of energy supply chain from the point of view of system optimization. Therefore, taking the residual by-product gas system as the main research object of the energy supply chain, on the basis of scientifically reducing its emissions, the characteristics and existing problems of its energy supply chain are analysed, which is of great significance to the economic development of the iron and steel complex. At the same time, it lays a theoretical foundation for the integrated scheduling and operational robustness evaluation of the energy supply chain of the following self-provided power plants based on the systems engineering.

2. Energy Supply Chain of Self-provided Power Plant in Iron and Steel Complexes

2.1. The Meaning and Characteristics of Energy Supply Chain

The concept of supply chain has been widely used in the production process of physical products [12-13]. This paper introduces the meaning of "energy supply chain" from the point of view of energy consumption, taking the production and consumption of energy as the main line, includes:

(1) The main purpose of the energy supply chain is to provide the energy products for the internal users of the complex, so that the complex can make reasonable use of the primary energy which is converted from the primary energy production.

(2) The energy supply chain system is composed of multi-sector, multi-process and multi-resource elements, and the research from the process needs to involve many links, such as energy supply, processing conversion, distribution and so on. Therefore, a network supply chain consists of multiple processes.

(3) The complex at each node must adjust its production according to the needs of downstream customers within the complex because the energy supply chain is an open supply chain system. The complexes at each node will make corresponding production plan according to the influence of policy and season.

Based on the above analysis, it is considered that the energy supply chain is to meet the needs of users, achieve the balanced supply of energy, the integration of primary energy supply, the conversion of primary energy to primary energy, and the integration of multiple energy flows, which can ultimately be distributed to users and under certain conditions. Other operation activities, so as to realize the synchronous operation of logistics, information flow and capital flow, and through a multi-department, multi-process, multi-resource supply chain system. It also can integrate multiple departments, multiple processes and multiple resources through other business activities to achieve the synchronous operation of logistics, information flow and capital flow. The energy supply chain diagram is shown in figure 1:
2.2. *The Composition of Energy Supply Chain for Self-Provided Power Plants of Iron and Steel Complexes*

The energy supply chain is very complex in actual production. There are a wide range of primary energy, such as electricity, steam, gas, water and so on. The primary energy includes various by-products such as gas, waste heat and residual energy for self-provided power plant. Among them, the gas resource is the main primary energy produced, excluding the low-temperature waste heat such as cooling water. If all the energy supply of the entire self-provided power plant is reflected in the energy supply chain, a great deal of research work is required; there are a very low proportion of energy that has little impact on the steel industry and urban development in the meanwhile. Therefore, the energy supplied by their energy suppliers mainly includes gas, coal, water and electricity purchases, some of which are purchased energy from the energy supply chain system. Taking into account the actual situation and highlighting the focus of research, the composition and organizational structure of the energy supply chain are simplified. The energy sources such as water and steam are not reflected in the energy supply chain, the primary consideration is the primary energy gas after primary energy conversion is flowed to the captive power plant, then to the distribution station in the supply chain network, and finally to the individual user’s simple energy network. The energy network diagram is shown in figure 2.

**Figure 1.** Schematic illustration of energy supply chain.

**Figure 2.** Schematic illustration of energy networks in Power plant of iron and steel complex.
2.3. Analysis of Energy Supply Chain of Self-Provided Power Plant in Iron and Steel Complexes

The energy supply chain of consists of primary energy, primary energy converts into secondary, multi-energy coupling and product distribution nodes according to this analysis. The supply raw materials including primary energy coal (purchased and local coal resources) and purchased electricity from the supply node of the energy supply chain.

(1) The suppliers supply coal to self-provided power plants and convert it into heat for internal or external users by means of coal-fired boilers. One part of coal is used for heating in self-provided power plants and for the use of employees, the other part of coal is used for production. It belongs to the end consumption and needs to generate heat through various energy flow coupling nodes formed by coal-fired boilers and coal-fired gas boilers, which meet the demand for heating terminal node users by the distribution centre distribution finally. 

(2) Iron and steel complexes as suppliers of gas supply to the self-provided power plants, through gas, coal-fired gas boiler and other ways into heat for internal or external use of iron and steel complexes.

Gas Suppliers (internal supply of iron and steel complexes) supply surplus gas to gas-fired and gas-fired boilers through reasonable dispatch. The remainder is supplied to industrial users, the industrial gas user is at the terminal node of the terminal supply chain, and the heat generated by various energy flow coupling nodes through the gas-fired boiler room can finally meet the thermal demand of users at the terminal node, such as the canteen.

(3) The water-power resources supply the water power and the pumped-storage hydroelectricity at the processing conversion node directly.

(4) The purchased power is mainly supplied to other power users. The purchased electricity will be imported into the power distribution centre together, and then reach the end users through the distribution network to meet the power demand. Based on the above analysis, the simplified diagram of the energy supply chain complex is shown in figure 3:

![Figure 3. Schematic illustration of energy supply chain in Power plant of iron and steel complex.](image)

3. Major Problems in the Energy Supply Chain of Iron and Steel Complexes

The energy supply chain of self-provided power plants has been improved after implementing policies such as adjusting industrial structure and optimizing energy composition, but there are still many problems, the main aspects are:
(1) The raw materials supply system of energy supply chain

Energy supply chain upstream energy raw materials are still mainly outsourcing. Steelmakers, which buy most of their primary energy, are woefully short of self-sufficiency. For example, coal is mainly purchased from abroad and is susceptible to the influence of foreign coal production and the constraints of transport conditions; the transmission of electricity purchased from abroad is susceptible to factors such as climate and external forces, which increases the possibility of power outages and greatly increases the risk of normal operation of steel complexes; the supply of gas systems mainly depends on the residual gas of steel complexes and the complexity of the gas system itself also challenges the stability of transportation. Now, the situation of the steel industry is still grim, the requirements for energy conservation and emission reduction are becoming stricter. The procurement of primary energy sources still depends on external energy sources, the rationality of internal conversion also needs to be improved. In terms of primary energy utilization, the stability of the whole energy supply chain of iron and steel complexes has been greatly challenged.

(2) The joint system of the energy supply chain

The joint complexes in the energy supply chain include the upstream complexes (such as the coke oven, the blast furnace and the converter process), the power complexes (mainly including the self-provided power plants and the power supply complexes) and the downstream complexes (such as the heating complexes). The supply and demand relations between these complexes constitute the supply chain, at the same time, they influence and restrict each other. In order to ensure the efficient operation of the whole supply chain, every node in the supply chain must be coordinated in real time, and has the stable effective supply chain control system, otherwise, it will cause the serious influence to the complexes.

During the operation of the energy supply chain, the price and market demand information of the final products, such as heat and electricity, are always fed back to the iron and steel complexes coal complexes and power generation complexes. In addition, coal, gas, electricity prices and supply and demand information will also be fed back to steel and other upstream complexes, which will have a certain impact on the production and operation of complexes in the energy supply chain.

The energy consumption structure of the node complex and the terminal complex of the energy supply chain processing conversion is unreasonable, resulting in low utilization rates. At the same time, under the current installation level and technical level of the complex, the overall efficiency of the electric motor and the thermal efficiency of the coal-fired boiler are low, which increase energy consumption, environmental pollution and energy waste. The structural layout of industrial coal and industrial gas at the terminal utilization node is also unreasonable. Factors such as low industrial concentration, serious pollution, high energy consumption, and low value-added industries have led to the unreasonable consumption structure, serious energy waste and low energy efficiency in the energy supply chain of self-owned power plants.

(3) The management system of energy supply chain

The management system of energy supply chain is not perfect enough and the reform needs to be further deepened. The energy supply chain is in the situation that the energy resources are imported and the energy products are exported for the downstream complexes, but the energy supply chain system is also dynamic because of the uncertainty of the market demand. At the same time, the management of the complex's energy supply chain is scattered in many sectors, lacking a unified and coordinated management mechanism, and it is difficult to take timely and effective responses measures for the domestic and foreign energy situation. The scientific and reasonable energy price system and the energy price linkage mechanism have not been formed, and the calculation of the energy supply chain logistics costs is also unreasonable, just like the "Iceberg Theory". Therefore, it is necessary to accelerate the reform of the existing energy supply chain management system in order to reduce the cost of government operations and management, and to adopt a standardized management system to improve the efficiency and management level of complexes, to formulate a scientific energy price system and energy price linkage mechanism to promote effective competition in the energy market.
(4) The environmental system of the energy supply chain

The energy environmental problem is prominent in the energy supply chain, because coal and gas play an important role in the energy consumption organizations. The energy consumption structure is dominated by coal and natural gas, and the direct combustion of a large amount of raw coal will also produce a large amount of carbon dioxide, sulfur dioxide, soot and industrial dust emissions, causing great damage to air quality and put a lot of pressure on the environment. In response, complexes and governments should allocate special funds for infrastructure construction every year to control pollution, energy consumption and economic development.

4. Conclusion

This paper analyses the composition of the energy supply chain of the self-provided power plants in detail, and then analyses and studies the main existing problems, aims at reducing the carbon emission in the supply chain, taking the energy supply chain as the research object. According to the current status of energy supply and the structure and characteristics of the energy supply chain, the content of the article mainly includes the following four aspects:

(1) The upstream energy materials in the energy supply chain are still mainly purchased from outside, and there are hidden dangers in the stability of energy supply chain system;
(2) The energy consumption structure of node complexes and terminal complexes is unreasonable and the utilization rate is low;
(3) The management system of energy supply chain is not perfect in self-provided power plant;
(4) The problem of energy and environment in energy supply chain is serious, which restricts the development of environment and economy.

This research will be continued based on this paper, the energy supply chain network structure will be optimized reasonably, the model operation stability is evaluated and optimized based on the gas system instability and burst condition.

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