Analysis of the Status Quo, Problems and Suggestions of the Development of Combined Heat and Power Central Heating in China Based on Big Data Technology

Lili Zhao1,*
1Liaoning Jianzhu Vocational College, Liaoning, China, 111000
*Corresponding author e-mail: 603275752@qq.com

Abstract. Combined heat and power (CHP) central heating is recognized as an energy preservation and environmental protection technology. Currently, CHP scale in China has ranked second in the world. Based on a retrospective analysis of China's related policies for CHP central heating, This paper studies the current situation of China's combined heat and power market and analyzes the market potential of China's combined heat and power based on big data technology. Big data analyzes the main obstacles to the use of combined heat and power in central heating and energy saving, and proposes policy recommendations to promote the development of combined heat and power in central heating.

Keywords: CHP, Central Heating, Policy Recommendations, Big Data Technology

1. Introduction
Combined heat and power is an efficient energy production method for the combined production of heat and electricity [1]. Since the 1980s, the government has issued a series of related policies for combined heat and power and central heating, which has played a positive role in promoting the development of combined heat and power and central heating in China [2]. Relevant policies in recent years mainly include: “Regulations on the Development of CHP” (2000), which stipulates the technical indicators, management methods and the relationship with the power grid of CHP, which is the main basis of the current CHP management. “Technical Regulations for Feasibility Study of CHP Projects” (2002), strictly manage and strengthen the preliminary work of CHP projects from a technical and economic perspective. The “Guiding Opinions on the Pilot Work on the Reform of Urban Heating Systems” (2003) put forward specific requirements for household metering of central heating, and promoted the commercialization and monetization of heat use [3-4], “Technical Guide for Urban Residential Metering Heating” (2004), guides localities to adopt corresponding technical measures in the design of central heating in residential buildings to meet the requirements of household metering and controllable room temperature. The “Special Medium- and Long-term Plan for Energy Conservation in China” (2004) pointed out that CHP and central heating are the main areas of energy conservation, and that CHP was listed as an energy preservation project separately in the top ten national key energy preservation projects [5], “Implementation Opinions on Promoting Heating Metering” (2006), put forward the objectives and technical measures for promoting heating
metering \cite{6}. “National Top Ten Key Energy preservation Projects Implementation Plan” (2007), in which the co-generation energy preservation project implementation plan proposes the important work content and supporting policies of co-generation during the “11th Five-Year Plan” period\cite{1}. This paper analyzes the main barriers faced in tapping the potential of central heating and energy conservation for CHP, and puts forward policy recommendations to promote the development of CHP central heating.

2. Development status of CHP central heating market

2.1. Development Status of Thermal Power Consumer Market

Collected from 2011 to 2015, China's terminal heat consumption (the caliber of heat consumption in the statistical yearbook is mainly for industrial enterprises, and its specific definition is: hot water and superheated or saturated steam that can provide heat sources, including the following: industrial boilers Public steam power stations, publicly-supplied thermal power plants and self-provided power plants, and externally-supplied steam. Excluding: self-produced steam for enterprises and hot water and steam provided by heating boilers with evaporation capacity below 2t / h. It is about 50%, and currently accounts for about 5% of the country's terminal energy consumption. The main sources of rapid growth in heat consumption are the industrial sector and the building heating sector. Industrial enterprises are the largest user groups of heat. Industrial production (including chemical, paper, pharmaceutical, textile, and non-ferrous metal smelting, etc.) requires heat as the basic energy source. Currently, except for some large industrial enterprises, which are supplied by their own thermal power plants, most industrial enterprises are provided by boilers. With the rapid development of central heating, the residential heating power consumption has increased from 8Mtce in 2001 to 17.6Mtce.

Generally speaking, the industrial sector is still the leading area of heat consumption, accounting for more than 70% of the country's total heat consumption. However, the heating consumption of residents' heating is growing faster than the industrial sector, and the proportion of total heating consumption in the country is increasing\cite{2}.

2.2. Development Status of CHP Market

China's CHP market has made positive progress in the past 30 years (as shown in Figures 1), and China's CHP installed capacity has ranked in the top two in the world. The installed capacity of CHP in China increased from 10GW in 1990 to 29.9GW in 2000, with an average annual growth rate of 11.6%; by the end of 2005, the combined installed capacity of heat and power further increased to 69.8GW, with an average annual growth rate of 18.5% from 2001 to 2005. The proportion of CHP in thermal power installed capacity continues to increase, from 11.3% in 1990 to 13.3% in 2000, and to 17.8% in 2005.

The power generation efficiency of a thermal power plant is shown in equation (1):

\[ q = \frac{Q'}{E/10} \]  \hspace{1cm} (1)

Where \( Q' \) represents the heat consumption (kj) for power generation in the thermal power plant during the calculation period;

\[ Q' = (A \times B + C \times 41816) \times D \]  \hspace{1cm} (2)

Where \( A \) represents the amount of coal consumed, \( B \) represents the low calorific value of coal, \( C \) represents the amount of oil consumed, and \( D \) represents the power generation ratio.
Figure 1. China's thermal power capacity and CHP installed capacity over the years.

By the end of 2006, there were a total of 2,606 heating units of 6MW and above in China. The total installed capacity is 80.48GW, accounting for about 18% of the country's total installed capacity of thermal power, and 14.6% of the total installed capacity of generating units in the country. The annual heat supply is 2275.65PJ, an increase of 18.18% over 2005. Currently, CHP has accounted for 81.2% of the country's total heating steam supply and 29.5% of hot water heating in China. Compared with the combined heat and power of heat and power, the energy efficiency of CHP generation can form about 67 million tce of energy conservation capacity.

2.3. Development Status of Central Heating Market

Central heating is a heating method vigorously encouraged by our government for a long time. From 2010 to 2015, the central heating area increased from 1108Mm² to 2521Mm², with an average annual growth rate of more than 17% (as shown table 1).

Table 1. Central heating statistics.

| Years | Number of cities | Heat capacity (GW) | Annual heating volume (PJ) | Pipe Length (km) | Pipe Length (km) |
|-------|------------------|--------------------|----------------------------|------------------|------------------|
|       | Existing cities  | Central heating    | Steam (t/h) | Hot water | Vapour | Hot-water | Steam tube | Hot-water line | Total | House |
| 2010  | 663              | 294                | 74100       | 97       | 238    | 833       | 8000       | 35800       | 1108  | 758   |
| 2011  | 662              | 304                | 72200       | 126      | 377    | 1002      | 9200       | 43900       | 1463  | 958   |
| 2012  | 660              | 315                | 83300       | 144      | 574    | 1227      | 10100      | 48600       | 1556  | 1080  |
| 2013  | 660              | 321                | 92600       | 172      | 591    | 1290      | 11900      | 58000       | 1890  | 1310  |
| 2014  | 661              | 324                | 98300       | 174      | 694    | 1282      | 12800      | 64300       | 2163  | 1508  |
| 2015  | 661              | 329                | 106700      | 198      | 715    | 1395      | 15000      | 71400       | 2521  | 1751  |

By heat source, central heating can be mainly divided into CHP generation, and district boiler room central heating methods. By products, it can be divided into steam and hot water.

The central heating data does not include industrial steam and hot water heating). The total heat supply (including steam and hot water) for central heating is 2110.3 PJ, of which CHP accounts for about 47%, and regional boiler houses account for 51%about. In the heat supply of steam and hot water, the total heat supply of steam is 714.9PJ, the CHP generation accounts for about 81%, and the regional boiler room accounts for about 17%; the total amount of hot water heating is 1395.4PJ, About 29%, the regional boiler room accounts for about 69%. The CHP of district heating and district boiler room heating is 992PJ and 1086PJ, respectively. Although the two sets of numbers are not much different, the main difference is in the different heating methods. Heating by hot water is more economical for the district boiler room. At the same time, CHP is dominant in the steam heating system, with a proportion exceeding 80%.
3. Barriers Faced

3.1. Institutional Barriers
Since combined heat and power and central heating involves the production of enterprises and the life of the public, there are several aspects involved in promoting combined heat and power and central heating. Mainly include: First, energy price policies need to be further rationalized. Currently, China's coal prices have been in line with the market. However, electricity prices and heat prices are still subject to government pricing or government guidance prices. In recent years, coal prices have increased rapidly, but the increase in electricity and heat prices has been small. At the same time, because heating affects the essential lives of residents, heating companies cannot shut down heating units at any time like ordinary commercial enterprises. Although the government has given some compensation to the heating companies, due to the need to rationalize the energy price policy further, a large number of thermal power companies and heating companies are facing severe survival problems due to poor business efficiency. Second, the reform of the heating system should be further deepened. Currently, most areas in China are still levying heat charges according to the area, and failing to charge according to heat. The advantages of central heating, energy conservation, and environmental protection have not been fully reflected, and it has affected the development of building energy conservation. To be resolved. Due to the barriers to grid connection for power generation, the development and application of combined heat, power, and cooling technologies have been affected[3].

3.2. Policy Barriers
In terms of economic incentives and administrative policies, support for CHP central heating needs to be strengthened. The main manifestations are as follows: First, the lack of fiscal and tax preferential policies for combined heat and power and central heating. Currently, there are few fiscal and tax preferential policies specifically for combined heat and power and central heating. Second, the lack of CHP projects operational supervision is encouraged. China has implemented a project review and approval system for new combined heat and power projects. However, during the project operation period, the lack of effective supervision led some power plants that passed the review in the name of CHP to operate as thermal power plants during actual operation, which reduced energy efficiency. Third, the lack of “small thermal power” and correct understanding of the different properties of “small thermal power” to save resources. In the development of the power industry, China advocates “upgrading the big and suppressing the small.” For small and medium thermal power units, due to high energy consumption and severe pollution, it should be eliminated. Because small and medium-sized thermal power units use combined heat and power, energy efficiency can be maintained at a high level and needs to be treated differently. However, currently, when new combined heat and power projects are newly launched, large units are always being encouraged, and small thermoelectric units are difficult to pass the review and approval. In addition, some small and medium-sized thermal power companies with higher energy efficiency levels were eliminated in the process of “upgrading and suppressing small.”

3.3. Financial Barriers
China's economy and society are in the process of rapid development. The overall planning of CHP central heating development faces insufficient funding. The main manifestations are as follows: First, some planned CHP central heating projects lack sufficient investment in heat network construction, which affects the construction and economic operation of the project; second, there are existing CHP central heating projects, and many Under the circumstances, the loss of the heating network is too significant, which affects the energy conservation effect. There is a lack of sufficient funding sources for the energy conservation transformation of the heating network. Third, in some cities and urban areas, industrial and residential heat consumption has developed rapidly, and there are certain problems. Certainty, leading to many CHP central heating projects often face investment barriers at the planning stage; the fourth is some new mechanisms that help to promote energy efficiency
financing barriers (such as “contract energy management”, “clean development mechanism”, etc.) involved in the CHP central heating sector, less involved.

3.4. Technical Barriers
Currently, it is necessary to learn from advanced technologies in combined heat and power and central heating in developed countries to promote central heating of CHP in China to achieve greater energy conservation, environmental protection, and social and economic benefits. In addition, for CHP central cooling technologies, there are still different views in China's academic circles, and most demonstration projects have not received significant energy conservation and emission reduction effects, and further research should be conducted.

4. Policy Recommendations
Further strengthen CHP central heating, rationalize the system and mechanism. Firstly, it is recommended that a special department to strengthen the overall planning capability of the CHP central heat supply industry should be established. China's development of CHP central heat supply should be studied and developed. Long-term planning, industrial policies, and technical policies should be formulated to promote the healthy development of the CHP central heating industry in China[4].

Secondly, actively promote the reform of the electric power system, allowing combined heat and power projects to be connected to the main grid, and encourage combined heat and power projects with reference to relevant measures to encourage renewable energy generation access to the grid.

Thirdly, deepen the reform of the heating system, rationalize the energy price formation mechanism and management system, and drive the healthy development of thermal power companies and heating companies.

Study and formulate preferential policies to encourage CHP central heating. It is recommended that the state should issue the “Regulations on the Management of Combined Heating of CHP” to formulate specific measures to support central heating of CHP in terms of economic incentives and administrative management. The specific recommendations in this regard include the following:

Firstly, study and formulate relevant preferential policies and measures in energy prices, financial subsidies, tax reductions, and other aspects to encourage central heat and power combined heat and power.

Secondly, strengthen the energy conservation assessment and review of new CHP projects, and enhance the supervision and management of the operation of existing combined heat and power projects by implementing the combined heat and power monitoring and certification system. The existing CHP projects should be monitored and certified every two years and linked to preferential policies to ensure that these projects operate in the CHP mode.

Thirdly, treat “small thermal power” and “small thermal power” differently and do not suppress “small thermal power” blindly.

Address the technical funding issue of CHP central heating. Firstly, carry out R&D and demonstration of advanced CHP central heating technology. Secondly, study and formulate technological standards and applicable conditions CHP. Thirdly, study energy preservation financing schemes for CHP central heating projects (for example, involving energy preservation service companies and commercial banks for the trial of CDM mechanism)[5].

5. Conclusion
According to big data analysis, we should strengthen international exchanges and cooperation. At the same time, it is recommended to speed up international cooperation in the field of combined heat and power central heating, and conduct research and preparations for the "International Cooperation Project on Energy-saving Combined Heat and Power Central Heating." In light of China's national conditions, learn from the policies and management experience of developed countries to promote combined heat and power central heating, vigorously introduce foreign advanced technology, and
encourage foreign institutions to invest in combined heat and power central heating projects in China\cite{6}.

References

[1] Bo Cai, Hongqiang Li, Yan Hu. Theoretical and Experimental Study of Combined Heat and Power (CHP) System Integrated with Ground Source Heat Pump (GSHP)[J]. Applied Thermal Engineering, 2017, 127(2),1-14.

[2] Schenk A, Gamper S, Grimmer C, et al. Development of Low Cost High-Temperature Polymer Electrolyte Fuel Cell Membrane-Electrode-Assemblies for Combined Heat and Power Plants in Single Family Homes[J]. ecs transactions, 2016, 75(14):435-441.

[3] Pavel Atănăsoae. The Operating Strategies of Small-Scale Combined Heat and Power Plants in Liberalized Power Markets[J]. Energies, 2018, 11(4):33-44.

[4] Xinyu Chen, Chongqing Kang, Mark O’Malley. Increasing the Flexibility of Combined Heat and Power for Wind Power Integration in China: Modeling and Implications[J]. IEEE Transactions on Power Systems, 2015, 30(4):1848-1857.

[5] Kaladhar Kolla, D Srinivasacharya. Combined effects of Hall, Joule heating and thermal diffusion on mixed convection flow in a vertical channel saturated with couple stress fluid[J]. Frontiers in Heat & Mass Transfer, 2016, 7(1):1-10.

[6] Wang Chaoran, Ruszkowski Mateusz, Yang H-Y Karen. Chaotic cold accretion in giant elliptical galaxies heated by AGN cosmic rays[J]. Monthly Notices of the Royal Astronomical Society, 2020,1(3):32-40.