GROWTH OF GEOTHERMAL DISTRICT HEATING IN CHINA

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ABSTRACT

Geothermal space heating was started later in China, when medium-low temperature geothermal resources was found in Beijing and Tianjin during geothermal exploration which initiated by the then Minister of Geology the famous geologist, Prof J.S. Lee in the early 1970s. After various geothermal heating tests were carried out, geothermal district heating was established in 1987 in Tanggu, Tianjin. It has served 100,000 inhabitants and a total construction area of *620.000* square meters there. It has been also enforced in Tianjin and will be in Beijing. Geothermal district heating has actually competitive advantages in economical and environmental aspects.

1. INTRODUCTION

There is long history in the utilization of hot springs in China. However, hot spring water was not used for heating. but for bathing and incdical treatment before. Perhaps it is the reason that most hot spring occurred in southern China where with warm climate. In the early seventies, abundant medium-low temperature geothermal resources were found in northern China such as Beijing, 'Tianjinby geothermal exploration. So that, geothermal space heating was applied spontaneously. Thereupon , it was put into test, and then was progressively developed towards standardized and large-scale geothemial district heating during the recent some 20 years. Geothermal district heating has manifested its advantages in economical and environmental aspects.

2. GEOTHERMAL *RESOURCES* EXPLORATION AND DEVELOPING UTILIZATION FOR HEATING

There are more than 2,700 hot springs in China. According to historical records ancient Chinese used the hot spring water mainly for bathing and medical treatment. The earliest record had been found in the "A prose Poem of Hot Spring" which written by ancient scientist Mr. Hen Zhang in the second century There is 3 "Flowing Cup Pavilion " in Malanyu Hot Spring located in northern Tianjin. The hot water was led to pass a narrow tortuous ditch which the shape of the letter W through the pavilion ground . Guests can drink a cup of heated wine there when the cup of wine has been floated on the hot water from the upper reaches to the lower reaches. But unfortunately we have not yet found an ancient example used hot spring water for space heating in historical record or in hot spring area. There is a plot of hot ground in Huangguaqing hot spring area, Tengchong county, Yunnan province. Local people constructed some simple house by bamboo on the ground. Somebody's lie on the ground which covered by dry grasses They are treated for some diseases Because they don't need heating even in winter season in the warm temperature zone

In the fifties and sixties. although a tew explorations were carried out in some hot spring area, but their purpose is for hot mineral water research which follows Russian expert's theory on "mineral water" So they are not for geothermal research

In the end of sixties, initiated by the then Minister of Geology, the geologist Prof. J. S. Lee, Some conditional geological bureaus started geothermal exploration and development including in some hot spring areas as a project of new energy sources. As a result, abundant geothermal resources were progressively found in northern China, such as Beijing, Tianjin, and Renqiu and Xiongxian of Hebei province in the early seventies. When the large artesian hot water gushed out the well head, local people spontaneously led the hot water into room by a simple pipe. They started the practice of geothermal space heating. For example, 3 geothermal well was completed in Beijing Railway Station in August 1991. The railway staffs used *20* meters long of iron piper to lead the artesian hot water with temperature *52°C* into their dormitory, an one story house. So that, they didn't use heating stove for the winter. A similar case happened in Tianjin Duck Farm. Staffs led the artesian hot water temperature 82°C from a then completed geothermal exploration well into two ranks of houses. They simply tested various radiators (tubular or plate-type, made from different material), and some geothermal heated beds and desks.

Figure 1: Location map of being mentioned geothermal resources

Cooperated with spontaneous users, geothermal scientists and engineers carried out a series of geothermal heating tests by using low temperature geothermal water. They measured water temperature and flow rate at inlet and outlets, monitored air temperature outdoor and room temperature in various rooms. Compared with design handbook, the test results were reported as that: the direct continuative heating by using low temperature geothermal water with 50-60°C, even in Beijing, where the calculated outdoor temperature of winter is -9°C, is available achieve the aim, compared with boiler heating. e.g. designed room temperature 18°C. So to the accompaniment of progressing of geothermal exploration, some users chose geothermal heating instead of boiler heating. They asked designing unit to design or reform their heating pipeline according to geothermal hearing test results. So that , some geothermal heating system were constructed within user's units. Beijing is located in temperature zone of **40** degree of north latitude. Single well geothermal heating using 50 - 64°C low temperature geothermal water has satisfied the demands of heating area of **2-4*10**^{4} m^2. To middle eighties. the sum total area of geothermal heating is **24*** 10^4 m^2 in Beijing (Zheng, **1989).**

At the same period, various geothermal space heating tests were also carried out decentralizedly in many other cities in northern China. In Tianjin Guest House the boiler heating system was changed their previous close cycle into open cycle system. Geothermal water of temperature **48°C** was preheated by previous boiler, then used for space heating at first, then used for bathing and washing. During oil exploration the North China Oil Field obtained some geothermal wells in Renqiu area, Hebei province. Geothermal water was exploited as their by-products to solve winter heating in their staff residential quarters. So they finished history to bum crude oil for heating. In ancient city Xi'an, and Yingkou and Dandong cities of Liaoning province, geothermal water found by exploration were also utilized as heat source of winter heating.

3. ENFORCEMENT OF GEOTHERMAL DISTRICT HEATING

Passing through testing and developing for many years: the advantages of geothermal heating had been recognized by more users. **And,** if want to gain large economical benefits, large-scale geothermal district heating system has to be constructed. But this idea met difficulty in performance.

Most of medium-low temperature geothermal resources are developed in small-scale now by decentralized users in China. No geothermal company enforces concentrated investment and exploration, then sells the resources to various users. Usually, factories or units located in a geothermal field asks drilling team to drill one or two wells within their ground to solve geothermal heating and bathing themselves. Even if there is a certain potential e.g. enough flow rate on their geothermal well, they don't want share their gaining with other bodys, but prefer to keep the potential for future , developing themselves. The Administration of Geothermal Resources of Beijing as one of governmental departments planned to combine some close neighbors to establish "Multi-well combining geothermal heating". Some concerned units were mobilized several times, but it produced little effect.

Under the united leadership of the government departments, geothermal district heating had been enforced in Tanggu district , Tianjin. There a lot of boiler in central Tanggu before. Chimneys looked like forest. Every units had their small boilers to solve winter heatmg themselves. It made heavy airborne pollution. The government decide to reform district heating system instead of previous small boilers. Geothermal water resources were used first. District boiler rooms perform Concentrated heat supplying for non-geothermal arca. **A** few boilers are used to solve the *peak* load in geothermal heating system. So that the Bohai Sea Oil Company drilled a well of depth 2,050 m, number TR-1 in their Oil New Residential Quarter in 1987. Geothermal water with temperarurc 74°C and flow rate of 130 m^3/h was extracted. and heated for an area of 6.3 * 10^4 m^2. In the winter of 1988 total 4 geothermal wells extracted water for 151 * 10^4 m^3. In the winter of **1989,** the extracted water and heated area are 207.6 * 10^4 m^3 and 31.8 * 10^4 m^2 respectively. To that winter of **1991.** total 11 wells extracted thermal water of temperature 65 - 74 °C for 310 * 10^4 m^3 , and heated an area **62** * 10^4 m^2. It is about **16.3%** of the sum of heated area in Tanggu. It serves 10 * 10^4 inhabitants there now.

There are two types of geothermal heating system in Tanggu. The main one is direct geothemial heating with peak boiler. In general geothermal water is pumped into heating system passing directly through circulating pumps. Then some of the used water is mixed with geothermal water and circulated again in the system: while, the remainder is pumped into separate pipeline for bath and domestic use. But during the coldest weather or failure of the geothermal well, a steam **boiler** is started to heat circulating geothermal water to improve heating efficiency The other case is indirect geothermal heating system using heat exchanger made of titanium plates to avoid geothermal corrosion. Geothermal heating uses the methods of large flow rate, lower different in temperature, and continuous heating in day and **night.** *So* it made indoor temperature well-distributed and stabilized in 16-26°C.

The economical efficiency of geothermal heating can be shown as compared to district boiler heating. District boiler heating has obviously increased efficiency and decreased cost by comparison with discentralized small boiler heating. But geothermal heating still has clear superiority. As an example, the comparison between the TR-5 geothermal well in Xingang, Tanggu and district boiler room in Xingang heating station (taking one boiler on the average) is shown in table 1 (Cao, **1992)**

This result is similar with those economical comparison analyzed by Frimannson **(1991).** Lienau and Rafferty (1991) and Yasuhiro **(1987)** in Iceland, United States and Japan respectively. As showing in the table, the running cost of geothermal heating is 3.66 Yuan (RMB) per square meter per heating season. And the cost for district boiler heating is 6.63 Yuan/m^2. By the way said the cost for small boiler is 17.76 Yuan/m^2. So the running cost of geothermal heating is just 55.2% of the district boiler. In addition, the energy consumption for geothermal heating, even if the electricity expense per unit area is about two times as high as the district boiler, but it saves numerous coal resources. Considering the status of geothermal district heating in Tanggu, 25,000 tons coal can be saved during the winter heating season for **4** months. Then it can be calculated that airborne dust and waste gasses as sulfur dioxide will be decreased very obviously. By the monitoring from the department of environment protection the atmosphere environment in **winter** is as follows: total suspended solid 0.24 mg/m^3, sulfur dioxide **0.06** mg/m^3, nitrogen oxide 0.06 mg/m^3. It accords with the demands of the quality standard of state II stage atmosphere environment.

Table 1. Annual Conversion Expenses for District Boiler and Geothermal Heating System

Investment	(10^3Yuan)	District Boiler	Geothermal
		5.280	**2.296**
Coal quantity	(10^3ton)	**7.5**	
Coal cost	(10^3Yuan)	705	
Water quantity	(10^3ton)	**41**	
Water cost	(10^3Yuan)	**14.4**	
Electricity quantity	(10^3kWh)	**486**	370
Electricity cost	(10^3Yuan)	**58**	**44.3**
Staff's wages	(10^3Yuan)	**58**	**6 4**
Depreciation charge	(10^3Yuan)	**211 2**	**91.8**
Repair expenses	(10^3Yuan)	**79**	**34** 5
Business management charge	(10^3Yuan)	67	**36**
Cost of water resources	(10^3Yuan)	*0*	**43.2**

Total	(10^4Yuan)	1 192.6	256 3
Cost perm'	(10^3Yuan)	66 3	36 6
Coefficient of investment efficiency		0 15	0 15
Total heated area	(10^3m^2)	180	70
Annual conversion expenses	(10' Yuan)	1.984 6	600 6
Conversion expenses per unit area	(Yuan/m^2)	11 03	8 58

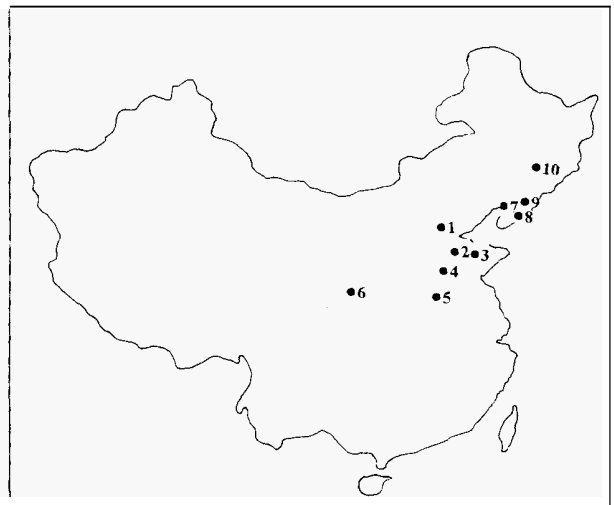
* Yuan is the unit of Chinese money (RMB) About 8 7 Yuan equals 1 US Dollar now.

4. PROSPECTS OF GEOTHERMAL DISTRICT HEATING IN CHINA

China is a developing country belongs to the Third World. On a poor foundation the socialist system had been enforcing the planned economy for long period. So the marketing economy develops slowly. A lot of good ideas should be done. hut it is lacking in funds. The environmental prohlems have been attached importance to. but it is limited by economical strength. All of these made geothermal district developed slowly

Rut undoubtedly, geothermal district heating has actually competitive advantages. Economically it has low cost. The data shown in Table 1 are conservative One of reason is that the investment of the geothermal wells was higher because the well located a non-anomalv area. so it has to be drilled deeper in order to get the same temperature than in geothermal anomaly area. The other reason is the coal price in the example was lower hecause about a half "planned coal" with low price included in, so the running *cost* of district boiler heating is relativelv lower.

Secondarily, problems on environmental pollution are followed with interest progressively by the government and the public The plan of "The Agenda of the 2 1 Century in China" has been passed. And it has obtained the World'? sport on the 1994 Beijing International Round-table Conference. China is enforcing actual to reduce the discharge of carbon dioxide and other pollutants. In order to clean the city air, a plan cutting down small boiler of winter heating and developing district heating will also he considered in conditional area e.g. as in the Zuojiazhuang residential area *in* Beijing.



1.Beijing 2.Tianjin 3.Tanggu, Tianjin 4.Xiongxian, Hebei Province 5.Renqiu, Hebei Province 6.Xi'an, Shanxi Province 7.Yingkou, Liaoning Province 8.Dandong, Liaoning Province 9.Benxi, Liaoning Province 10. Changchun, Jilin Province

Figure 2. Main geothermal district heatmg area in China

Moreover, many large-middle cities in northern China are rich in medium-low temperature geothermal resources It provides resource condition to geothermal district heating. The central area of Tianjin is located on Wanglanzhuang Geothermal field which had been explored. Its extracting heat resources have reached to 85 2 MW at present. Tianjin Municipal Government had made such a plan. The north Sport College residential area with total construction area of $88.3*10^4$ m^2 will put into effect progressively for geothermal district heating. The geothermal heating are3 there is about $10*10^4$ m^2 now. In addition, another one the Shanlingzi Geothermal Field located in the northern suburbs of Tianjin has completed resources exploration recently. It is another one belongs to large-scale medium-low temperature geothermal field with extractable thermal resources of 113 MW. In the southern suburbs of Tianjin, the Wangjiamatou third large geothermal anomalv area may be as the third large-scale medium-low temperature geothermal field in
Tianjin besides. An artesian geothernial exploration well with temperature 82°C had been dniled there before.

The Lake Baiyangdian Hot Spring City around the center of Xiongxian city, Hebei province is being constructed. All of new buildings and houses will install geothermal district hating there. The geothermal heating in the "Oil City" -- the North China Oil Field, located in Renqiu city, Hebei province, is being enlarged. A planned geothermal reinjection technique has been put into effect there, in order to continue the production life for the geothermal reservoir

5. CONCLUSIONS

Passing through the development and research for over 20 years, the progress on technology and economy. and enhancement on cognition for geothermal heating have been obtained within the practice utilizing the medium-low temperature geothermal resources. Although it is never that geothermal district heating has only virtues and without defects. But its virtues are dominant. We can make conclusion for geothermal district heating as **follows.**

5 1 Conversion expenses per unit area and running cost

Io compared with district boiler heating and other heating methods (e.g. electrical), the geothermal district heating has relatively lowest conversion expenses per unit and running cost. Its both values are about 77.8% and 55.2% of the district hoiler heating has rather high running cost. And the cost of electrical heating will be highest hecause lacking electricity in China

5 2 Environment aspect

Usually, Medium-low temperature geothermal water contains lower total dissolved solids. Its contents of chemical compositions, except fluoride in some cases. are acceptable in discharge standard. It is obvious that geothcmal heating reduced airborne pollution instead of boiler heating. It makes clean atmosphere in winter in northern China cities. It cuts down discharges of carbon dioxide and sulfur dioxide to atmosphere.

5.3. Reinjection and corrosion problem

Accompanying the increase of geothermal wells and their production rate. water level in geothermal reservoir has been dropping prugressively. It can be solved or improved by using reinjection. The North China Oil Field has been putting their producing simultaneously with reinjection into effect. Some key techmques. such as to prevent blocking up and to dispose deposit. had been controlled. Now some rcinjection wells have been prepared in Beijing. Tianjin and Tanggu. New geothermal reinjection techniques are being tested. Some research projects, e.g.

preventing geothermal corrosion, renewal of geothermal well, reducing heat loss in long distance transportation of thermal water and so on, are being carried out at present. All of these will make the techniques of geothermal district heating perfect.

5.4. Prospects

Along with the improvement of living condition of Chinese people, increase of state economical strength and the further enhancement of environment consciousness of the state and the public, the abundant medium-low temperature geothermal resources in many large-middle cities in northern China will bring the superiority into full play in geothermal district heating.

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7. REFERENCES

Cao, J. (1992). Geothermal District Heating System in Tanggu. Tianjin, China. GHC Bulletin. Vol. 14(2).pp.11-15.

Frimannson. H.(1991). Hitaveita Reykjavik after 60 Years of Operation-Development and Benefits. GHC Bulletin. Vol.13(4).pp.1-7.

Lienau P J and Rafferty K P E (1991) Geothermal District Heating System City of Klamath Falls GHC Bulletin Vol 13(4) pp 8-20

Yasuhiro M (1987) A Study for the Use of low Enthalpy Geothermal Water for District Heating In Proceedings of International Symposium on Geothermal Energy Exploration and Development of Geothermal Resources Geothermal Research Society of Japan Tsukuba, pp 47-350

Lheng. K.(1989) The Comprehensive Research of the Development and Utilization of Geothermal Resources in Beijing Urban Area Report for the Ministry of Geology and Mineral Resources. Beijing 144pp (in Chinese)