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GEOTHERMAL UTILIZATION AND ECONOMIC DEVELOPMENT IN TIANJIN

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ABSTRACT

In the early 1070's, Tianjin began exploration, research and development of geothermal resource. Low-medium temperature geothermal resources have, since then, been utilized directly in cascaded use, as a new energy source in Tianjin, China. The resources are utilized in space heating, agricultural greenhouses, aquaculture, bathing, medical care etc. During the 1980's, great achievements were reached, mainly because the state continued to fund geothermal development. Since the 1990's, the geothermal market has broadened and large progresses has been made with the rapidly developing technology and methodology, and the growing need for geothermal resource in Tianjin. The total area of geothermal space heating reached 12 million m² in 2007. Geothermal development plays an important role in Tianjin's economical development. Four new geothermal towns have been set up in the main geothermal fields.

1. INTRODUCTION

Hot springs have been used for bathing and washing for thousands of years in China and China is now at the top of the list in direct use of geothermal energy in the world. The growth rate of geothermal utilization in China has been greater than 10% per year during the last few decades. In the North of China, low-medium temperature geothermal resources are plenty and widely used for space heating, bathing, agriculture and aquaculture. There has been a great increasing in geothermal utilization in recent years following the growing market economy in Tianjin. By Year 2007, there were a total of 314 geothermal wells in Tianjin; the hot water production reached $25,838 \times 10^3 \text{ m}^3$; geothermal was used for space heating for an area of about $12,000 \times 10^3 \text{ m}^2$; and there were 100×10^3 families who used geothermal hot water daily. It is fair to say that the geothermal utilization has served the economical development in Tianjin.

2. GEOTHERMAL EXPLORATION

The exploration of geothermal resources in Tianjin started in the early 1970's. A geothermal investigation campaign was launched under the guidance of Prof. Li Siguang, and 10 geothermal anomalies were delineated in an area of 8700 km² to the south of Tianjin (Figure 1). The former Ministry of Geology and Mineral Resources aided the geothermal exploration in 1980's by invested 80 million yuan RMB. The exploration included large-scale investigation in the Wanglanzhuang and Shanlingzhi, geothermal fields.

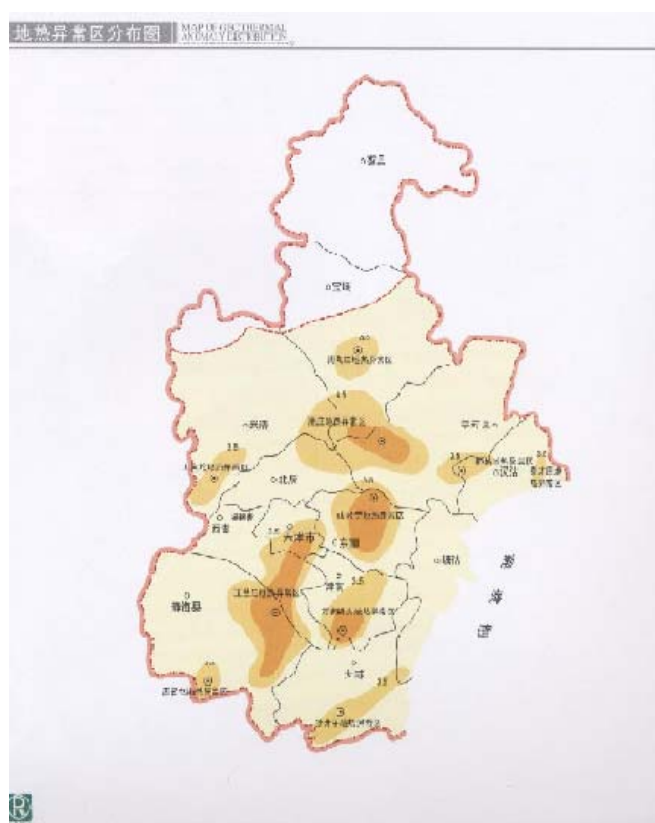


FIGURE 1: Geothermal anomalies

TABLE 1: Geothermal fields

Geothermal field	Tectonic	Area (km ²)	Geothermal gradient (°C/100m)
Wanglangezhuang	Shuangyao uplift	534	8.0
Shanlingzi	Dongzhuang uplift	315	8.3
Wanjiamatou	Xiaohanzhuang uplift	235	8.8
Panzhuang	Panzhuang uplift	610	6.9
Zhouliangzhuang	Wangcaozhuang uplift	180	5.5
Binhai	Ji zhong depression	2000	3.0
Jinghai		190	4.5

In the 1990's, geothermal exploration and evaluation was carried out in the costal areas of the Wuqing and Binhai areas. After year 2000 the Zhouliangzhuang, the Panzhuang, the Wanjiamatou, and the Jinghai geothermal fields have been explored (Table 1). At present, there are seven geothermal fields which reserves have been estimated by the National Reserve Administration Department (Table 2).

3. GEOTHERMAL RESERVOIRS

The geothermal fields in Tianjin are low-medium temperature geothermal resource with the unique characteristics of regional distribution. The main geothermal field is surrounding the urban area. Other geothermal fields are located outside of the city. Five horizontal reservoirs are located successively at a depth of 1000m - 4000m (Figure 2). The reservoirs are of two main types: Porous sandstone reservoirs of Tertiary age including the Minghuanzhen and the Guantao formations, and fractured limestone reservoirs in the bedrock including the Ordovician system, the Cambium system and the Wumishan formation of the Jixian system. The reservoirs have good potential and can be developed for space heating in winter, agricultural greenhouses, aquiculture, bathing, medical care etc. geothermal water is of good quality and medium temperature. The maximum temperature of the water is 103°C. A single well discharge ranges from 102-150 m³/h with a maximum of 340 m³/h. The geothermal resource is estimated at about 60 million m³/a.

TABLE 2: Geothermal resources reserves ($10^3\text{m}^3/\text{a}$)

Geothermal field Resource reserves		Wanglanzhuang	Shanlingzi	Binhai	Wuqing	Wanjiamatou	Panzhuang	Jinghai	Total
		Tertiary	Total reserves	15,210	6,010	10,440	1,180	730	3,100
	Reserves class	B	C	B+C	C+D	C+D	C+D	C+D	-
	Minghuazhen	9,887	3,907	6,786	767	730	3,100	3,160	28,336
	Guantao	5,323	2,103	3,654	413	-	-	-	11,494
Bedrock	Total reserves	6,260	11,780	-	-	2,100	-	-	20,140
	Reserves class	B	C+D	-	-	-	-	-	-
	Ordovician system	1,815	3,416	-	-	-	-	-	5,231
	Hanwu system	63	118	-	-	-	-	-	181
	Jixian system	4,382	8,246	-	-	2,100	-	-	14,728
Total		59,970							

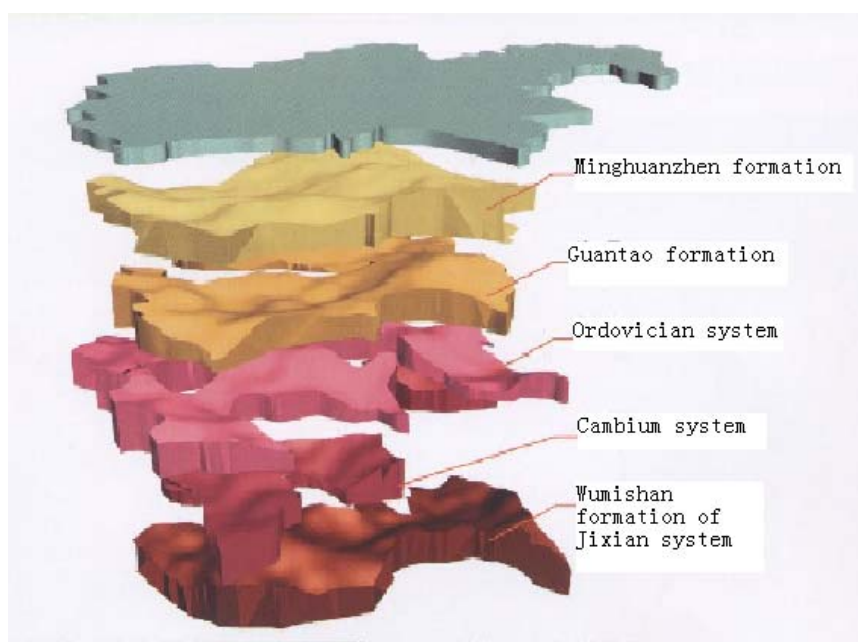


FIGURE 2: Geothermal reservoirs in Tianjin

4. GEOTHERMAL UTILAZATION AND ECONOMIC DEVELOPMENT

The rate of geothermal resources utilization is according to the reservoir characteristics and the demand for geothermal energy. The geothermal resources are mainly used for space heating, tap water, greenhouse, aquaculture, bathing etc. Geothermal utilization has been proven to have good economical, social and environmental benefit.

In many instances, geothermal exploration and development has played an important role in Tianjin's economical development, by being an attracting investment opportunity, improving on the quality of

the environment, improving on the living standard of inhabitants in geothermal development, expanding on tourist resorts and developing industrial and agricultural productions (Figure 3).

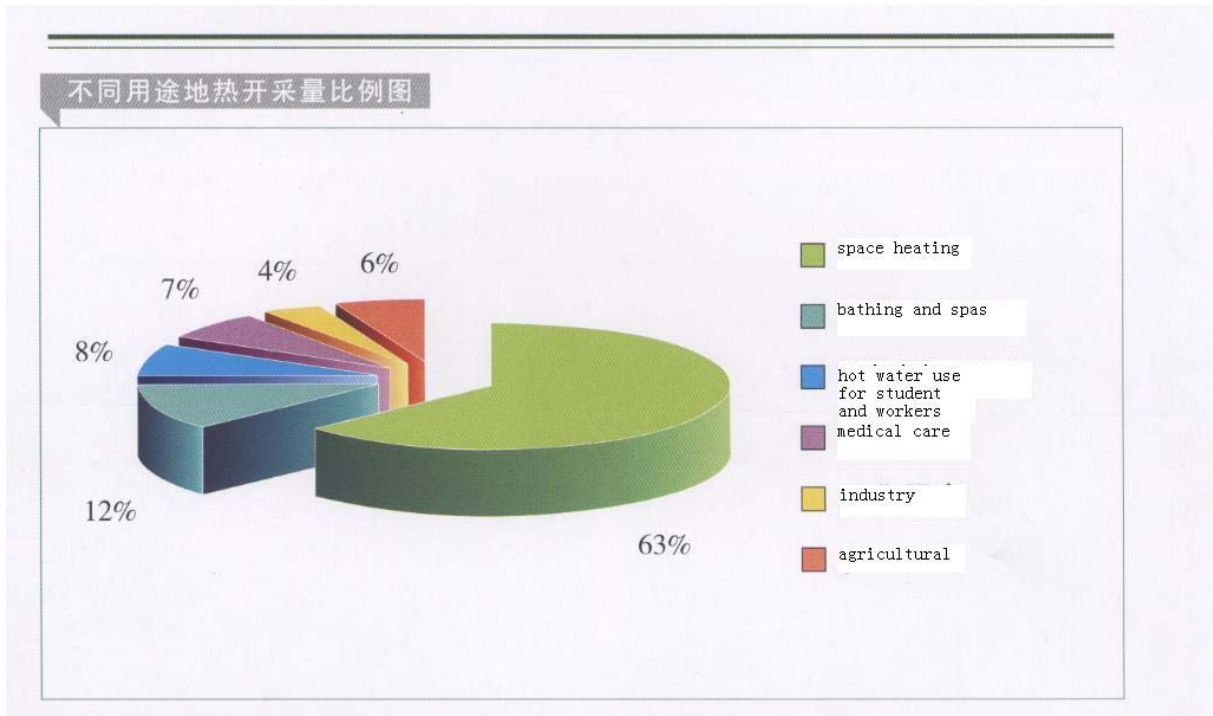


FIGURE 3: Geothermal utilization in Tianjin

Tianjin was the pioneer city in geothermal space heating in China and Wanglanzhuang geothermal field was the first field explored in Tianjin in the 1980's. There are 4 geothermal reservoirs in the Wanglanzhuang geothermal field: the Minghuanzhen sandstone porous geothermal reservoir in the Tertiary system and the limestone fracture reservoirs in the bedrock including the Ordovician system, the Cambium system and the Wumishan formation of the Jixian system. The sizes of reserves achievable for development are 21.47 million m³/a. Geothermal energy is widely used for space heating, and in Tianjin the heating area reached 12 million m² in 2007. This is the greatest area of geothermal space heating in China. According to the "report of the present state of geothermal resources development and utilization in China" by China Geological Investigation Bureau the geothermal space heating area in Tianjin is more than half of the total space heating area in China. Geothermal hot water is supplied to domestic households, enjoyed by more than 10 million workers and students for washing and bathing. The total area of hot spring swimming pool has reached 20,000m², and a multi-purpose utilization pattern has formed in Tianjin.

Tuanbo New Town is situated in the southern part of the Wanglanzhuang geothermal field 16 km south of Tianjin. The designed area is 210 km² and the future population is estimated at 600,000. It will be built as a cascaded live ecosystem for recreational holidays, business meetings with an exhibition centre, educational training centre etc. A high degree of internationalization is expected of the New Town ecosystem.

Tanggu is the national economic development area of the Binhai district. The Binhai geothermal field was explored in the 1990's. The amount of hot water that can be extracted from this field is 10 million m³/a. The geothermal reservoirs are in the Tertiary system including the Minghuanzhen and the Guantao formations. The water temperature is 46-78°C, and the quality of the water is good. The

single well production is 50-160 m³/h. 35 geothermal production wells have been drilled since the 1980's. The total production of geothermal water is more than 5 million m³/a. Most of the geothermal energy is used for space heating for an area greater than 1 million m². About 180 office buildings, schools, and kindergartens have been using geothermal water daily. 18,000 families or 120,000 residents are using the geothermal water for bathing. A 3 million USD loan was granted from NIB&NDF in 1993 for geothermal development in Tanggu. TGREC was setup in 1996, with the aim to study geothermal energy and utilization. The Wanke Crystal Town is located between the Urban area and Binhai district in Tianjin. It covers an area of 85.51 km². It is one of the top eight travel destinations in China and comprises seven of the natural protection districts in Tianjin. The town is located in the Sanlingzi geothermal field that was explored in the 1990's. The reservoirs in this area include all five geothermal reservoirs mentioned in section 3 (Figure 2). The total reserve in this area is 57.3 billion m³ accounting for a total geothermal energy of 3.58×10¹⁵ J. The extractable geothermal resource is 17.79 million m³/a. The Geothermal water is used for space heating, swimming, bathing and spas. The space heating area will soon reach 4 million m². Dongli Lake Hot Spring Resort and Wanke Crystal Town are the largest hot spring resort in Asia.

Jingjin City is located in the Zhouliangzhuang geothermal field 100 km southeast of Beijing and 70 km north of Tianjin. Four geothermal exploration wells have been drilled from 2003 to 2007. It is a low-medium temperature geothermal field including the same five geothermal reservoirs as the Wanke Crystal City. The storage of geothermal water is 8.6 billion m³. The capacity is 154.59 MW. The extractable geothermal resource is 7.38 million m³/a (Table 3). The temperature of the Wumishan formation of the Jixian system reservoir is more than 100°C. The pressure of the reservoir is 0.4 Mpa, and the maximum discharge is 340 m³/h. The quality of hot water is better than that in other geothermal field. The water is HCO₃-Na and HCO₃·SO₄-Cl-Na rich, with total dissolved solids of 1~1.2g/l. The geothermal water contains minerals that are beneficial for the human body. The total investment for the City is 20 billion RMB, and the total building area is more than 6 million m², with small houses, hotels and city centre.

TABLE 3: Zhouliangzhuang geothermal field characteristic

Reservoir	Production (10 ⁶ m ³ /a)	Capacity (MW)	Reserves (10 ⁹ m ³)
Tertiary	2.31	8.11	6.9574
Ordovician	0.45	7.50	0.1197
Cambium	0.32	8.77	0.1520
Jixian	4.30	130.21	1.373
Total	7.38	154.59	8.6021

5. CONCLUSIONS

Low- to medium-temperature geothermal resources are utilized for cascaded direct uses as new energy source in Tianjin. The geothermal utilization has played an important role in the economical development in Tianjin, and the Binhai New District is a considered the national economic development area. Three thermal spring resort areas have been developed in Tianjin: The Wanke Crystal Town and The Dongle Lake Hot Spring Resort area are located in the Shanlingzi geothermal field, and the Jingjin City was constructed as a part of the Zhouliangzhuang geothermal field development. Tuanbo New Town will bring about a high degree of internationalization in the New Town ecosystem.

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