THE GEOTHERMAL DEVELOPMENT AND UTILIZATION IN TIANJIN, CHINA

Kun WANG[1], Jinshu HAN[1] and Youjun WANG[1]
[1]Tianjin Bureau of Land, Resources and Housing, 84 Qufu Road, Tianjin 300042, China
E-mail: kun1302@sina.com

ABSTRACT

The geothermal resources in Tianjin is belongs to the typical low-medium geothermal resource in sedimentary basin. The geothermal distribution area is 8700 km^2, about 77% of the total Tianjin area. As a clean energy, the geothermal resourced is widely used on space heating, living water and agriculture etc. The annual production rate reaches $2500\times10^4m^3$ in 2005, and the space heating area is about 10 Mm^2, nearly half of the total geothermal heating area in China. To meet the rapid increasing of the demand for geothermal resources, it is necessary to enhance the prospecting precision, expanding the exploitation area and strengthen the basic technology research. The geothermal reserves of 4 new geothermal field have been proven up and the new attainable resources is $3290\times10^4m^3/a$ in 2005. Meanwhile the reinjection tests and research have been continued in Tertiary system and base rock. Aiming at the difficulties for measuring, fee collecting and monitoring during the administration, research and development for intelligent management NetPC system of geothermal wells are carried out. This system can make real time monitoring to every developer, raising the ability and level of geothermal administration to a new level.

Keywords: Geothermal resources, utilization, reinjection.

1. INTRODUCTION

Tianjin is one of the biggest city in China, which is located at the Bay of Bohai, the northeast of Huabei Plane. Its total area is 11,000km^2. It is the important traffic hinge and is about 120km southeast of Beijing

The Tianjin geothermal field is a typical sedimentary basin low-temperature system, which are common in eastern and northeastern China.

The development of geothermal resources in Tianjin started in early 1970s.Till now, 10 geothermal anomalies were delineated in an area of 8700 square kilometers to the south of the Baodi-Ninghe Fratcture. (Fig.1).

Aided by UNDP, the former Ministry of Geology and Mineral Resources invested 80 million yuan in geothermal exploration in 1980s, including large-scale investigation and exploration on Wanglanzhang and Shanlingzi geothermal anomalies.

In 1990s, geothermal exploration and evaluation were carried out in the coastal area and Wuqing County. At present, there are four geothermal fields whose reserves have been proven up by national reserve administration department.

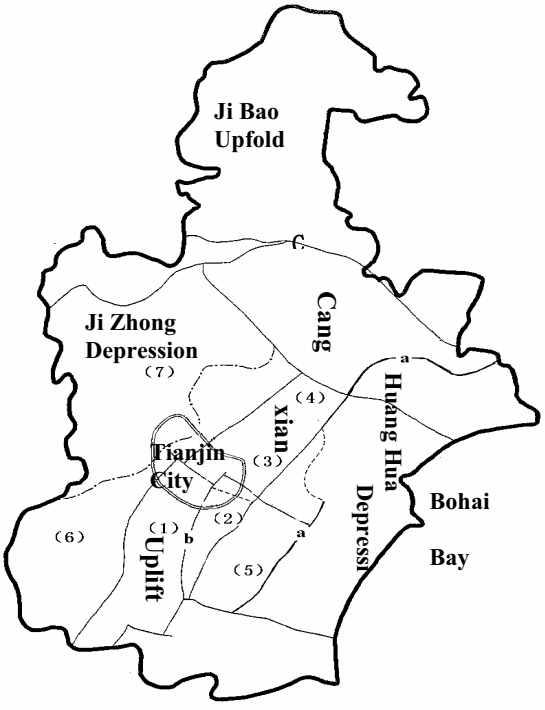

Fig.1 The sketch of the geological tectonic in Tianjin
a: Cangdong Fracture; b: West Baitangkou Fracture;
c: Baodi-Ninghe Fracture;
① Shuangyao uplift; ②Baitangkou depression;
② Daxiaodongzhuang uplift; ④Panzhuang uplift;
⑤Xiaohanzhuang uplift; ⑥Dacheng uplift;
⑦Wuqing depression.

2. GEOLOGY CHARACTERISTICS

Since Holocene epoch, the regional sea level ascends. Several times transgressions supply the salty materials for the wedge-shaped salty water mass, which is thin in west and thick in east in the Quaternary aquifer. The rising of the regional base level of erosion hindered the horizontal movement of geothermal water. The upright heat flow is obstructed by the huge thick Quaternary stratum and water mass. The sealing state is in favor of the heat-up of geothermal water. Although the sealed water moves slowly, it has quite fast velocity in decompression zone.

The geothermal water mainly located in the range of Cangxian uplift. They are "fractured karst geothermal water in bedrock", accumulated in medium Pro-terozoic Jixiannian Wumishan (Pt_2W), lower Paleozoic Cambrian (PzH) and Ordovician (PzO) reservoir; and "porous geothermal water in clastic rock" exists in Tertiary and Quaternary. The cold underground water deposits in the fissure of the basement in front of the Yanshan Mountain and the shallow porous/fracture aquifer (500-800m depth) in Tertiary and Quaternary. As the isotope analysis, geothermal water geothermal water come from the precipitation seepage in latest glacial period of upper Pleistocene (10000-21000B.P.), and sealed up to the present since Holocene. It is a closed deep circular system.

The fractured geothermal water in bedrock has the near ^{14}C value (15-4.5 pmc), bigger than the value of porous water(7.6-4.5 pmc). So the bedrock geothermal water is younger than porous water. After the denudation of long geological period, the bedrock has a huge weathering shell and well-developed fracture and dissolved cavity. Meanwhile there is a large outcrop area in the north and west mountains, so it is semi-closed reservoir. In the other hand, the reservoirs in Tertiary and Quaternary system have a good closed condition. Hereby, the deep circular geothermal system can be divided into:

(1)semi-open and semi-closed bedrock subsystem, where the karst geothermal water exists;

(2)closed clastic rock subsystem, where the porous geothermal water exists.

3. GEOTHERMAL UTILIZATION IN TIANJIN

The geothermal utilization history can be traced back to 1930s. In 1979 the first geothermal well in bedrock was drilled.

As a clean energy, the geothermal resourced is widely used on space heating, living water and agriculture etc. By the end of 2005, there are at least 224 geothermal wells in Tianjin, with more than 70 geothermal well drilled in basement reservoir The annual production rate reaches $2500\times10^4m^3$ in 2005, and the annual reinjection rate is $360\times10^4m^3$, which takes about 14% of the production rate.

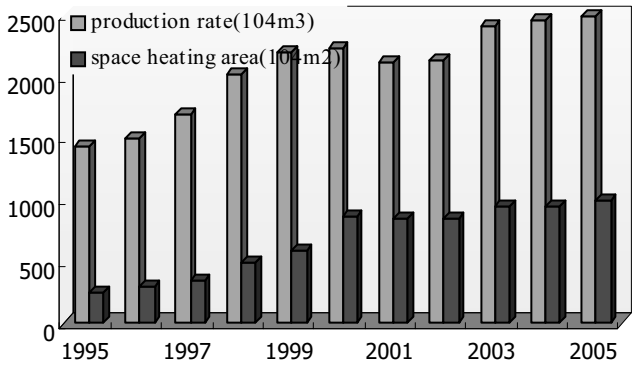

Fig.2 The geothermal development in Tianjin during1995～2005

Geothermal energy is widely used for space heating, and the heating area has reached 10,000 m^2, taking the first place in geothermal heating in China. According to "Peport of the present state of geothermal resource development and utilization in China" by China Geological Investigation Bureau, geothermal heating area in Tianjin makes up almost half of that in China. For domestic use, hot water has been provided to 95,000 households. Every year, 10 million person-time of workers and students use hot water for bathing. Total area of hot spring swimming pool has reached 20,000m^2. Mineral water production is 60,000m^3. Geothermal cultivation and planting area add up to 300mu. A multiple purpose utilization pattern has been formed.

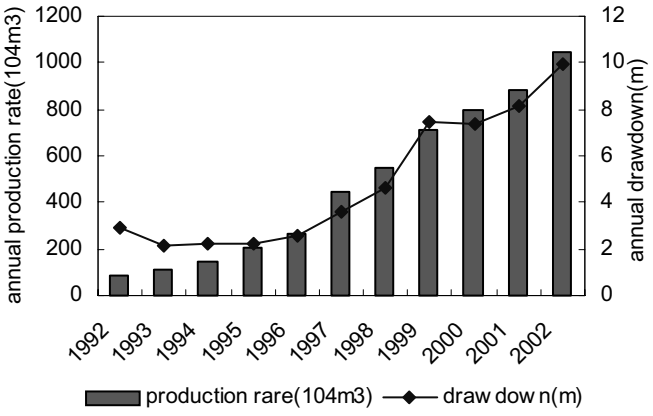

Fig.3 History curve of the water level drawdown and production rate in medium Proterozoic Jixiannian Wumishan group around urban area from 1992--2002

The Jixianian Wumishan group reservoir dispreads widely in Tianjin. The reservoir top depth is 988-3000m or so. The porosity is 4%-7%. The karst fracture developed in this reservoir and formed strong storage ability. It is the main productive reservoir in Tianjin area. Fig.3 is the history curve of the water level draw down and production rate around city urban area from 1992----2002. Since 1997, the annual water level draw down goes beyond 3m. Till 2002, it goes up to nearly 10m in 2002. This suggest that the recharge to Wumishan group reservoir has been reduced very quickly. Reinjection will be a necessary way to keep the sustainable development of geothermal resources in Tianjin.

4. REINJECTION IN TIANJIN

Reinjection means that the heat carrier—water is injected back to the reservoir after the heat energy is extracted by heat

exchanger in heating system, so that it can absorb heat energy again from the rocks containing rich heat. In this way, much more geothermal energy can be gained while the water carrier is kept equivalent. The use of reinjection techniques recycled heat carrier, forming a relatively sealed heat circulation system from underground to the surface. The purpose is to use only the heat energy and not to consume the water, so that the life of geothermal fields can be prolonged effectively.

By the end of 1980's, the reinjection tests had been carried out in Tertiary sandstone reservoir in Tianjin. During the tests, about 30～50m^3/h waste water were injected into the reservoir. But along with the continuing of the reinjection, the reinjection rates decrease quickly. The similar results were acquired in the reinjection tests in the winter between 2004～2005 . The mainly existed problems of the reinjection in Tertiary is : (1) reinjectivity decreasement or un-stability during the reinjection process ; (2) the plugging in the reservoir, including the types of physical, chemical and biological.

Since 1996, the reinjection test started in the basement reservoir in Tianjin. Till now there are 13 doublet geothermal systems, 10 of them are located in urban area. Both of the production and reinjection wells were drilled into the Wumishan group of the Jixianian formation in the Proterozoic(Wang Kun et al, 2001). The reinjection rate reaches 100 m^3/h in every reinjection well.

5. MONITORING SYSTEM OF THE GEOTHERMAL WELLS

Monitoring of the geothermal wells is an important job for the geothermal development.
Since 1980s, the geothermal monitoring projects started in Tianjin for measuring the water level, temperature and flowrate of the geothermal wells. It mainly provide information for geothermal survey and geological prospect. Along with the improvement of the monitoring measure and layout, an geothermal monitoring system had been set up in mid 1990s.

Aiming at the difficulties for measuring, fee collecting and monitoring during the administration, research and development for intelligent management NetPC system of geothermal wells are carried out in 2005. This system can make real time monitoring to every developer, raising the ability and level of geothermal administration to a new height.

In future, long-term monitoring of the Tianjin geothermal field must be further improved and equipped, so that any changes caused by reinjection will be observed as soon as possible.

6. GEOTHERMAL MANAGEMENT

The Tianjin Municipality attaches great importance to geothermal resources management. In 1995, the government issued "Stipulation of Geothermal Management in Tianjin". According to the Stipulation, in order to improve the security of geothermal resources and strengthen the saving and conservation of the resource, a new turn of planning "Plan of Geothermal Resources Development and Utilization in Tianjin(2006-2010)" has been compiled in 2005.

To meet the rapid increasing of the demand for geothermal resources, it is necessary to enhance the prospecting precision, expanding the exploitation area and strengthen the basic technology research. The geothermal reserves of 4 new geothermal field have been proven up and the new attainable resources is $3290\times10^4 m^3$/a in 2005.

Meanwhile the reinjection tests and research have been continued in Tertiary system and base rock. It Is planing that 33 reinjection and production doublet system will be build in 2 or 3 years. Thus, more than $600\times10^4 m^3$/a waste water will be reinjected into the reservoir.

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Improved use of geothermal resources, limitation of front-end costs and increased ground heat extraction are the keys to a steady development of conventional geothermal energy. GHP systems are taking more and more important role in space heating system. It is already replicated in many projects.

A very efficient way to heat and air-condition homes and buildings is the use of a geothermal heat pump (GHP) that operates on the same principle as the domestic refrigerator. The GHP systems can be used on dealing with the waste water of high temperature, or extracting more energy from the reservoir of lower temperature. The GHP can move heat in two ways: during the winter, heat is withdrawn from the earth and fed into the building; in the summertime, heat is

removed from the building and stored under-ground. In some GHP systems heat is removed from shallow ground by the means of an antifreeze/water solution circulating in plastic pipe loops (either inserted in vertical wells less than 200 m deep which are then backfilled or buried horizontally in the ground). In other GHP systems flow water produced from a shallow borehole through the heat pump, discharges the water either in another well or at surface. The heat pump unit sits inside the building and is coupled either with a low-temperature floor or wall heating net or with a fan delivering heat and cold air.

From the beginning of 2000, the geothermal management department has initiated the projects to evaluate those areas with the most promising geothermal potential. Research is also being carried out into deep-seated resources and reinjection tests in Tertiary system. In addition to various other governmental research organizations, private sector research bodies are also involved.

7. SUMMARY

Tianjin was ranked first in China with respect to the geothermal direct utilization. In recent years, geothermal developments increase rapidly and have reflected striking features of industrialized development under the promotion of market economy. The geothermal resources exploration, development and management is being strengthened progressively, too.

The geothermal exploration and development of resources had been playing an important role in many aspects for Tianjin's economical development, such as in attracting investments, improving environment quality and the living level of people, expanding tourism resources and developing industrial and agricultural productions. The geothermal utilizations made good economical, social and environmental effects. For example, the geothermal energy on space heating can be equivalent to 59.82 tons of coal every year, reducing 4,306 tons of coal dust discharge, 18,460.04 tons of SO_2 discharge, 5,539.13 tons of oxide of nitrogen and 475,600m^3 of CO discharge.

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