STRATEGIES OF SUSTAINABLE DEVELOPMENT AND UTILIZATION OF GEOTHERMAL RESOURCES IN TIANJIN COAST NEW DISTRICT

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ABSTRACT

There have been 109 geothermal wells in Tianjin Coast New District by the end of 2005. The annual production is 9.184×10^6 m^3. The highest utilization efficiency of geothermal energy is 62.4% and the geothermal reinjection rate is less than 3%, the geothermal exploitation use is extensive. The paper puts forward the proper using ways corresponding to the characters of different reservoirs in Tianjin Coast New District and increase the use rate of geothermal resources. The paper points out that increasing the reinjection wells and enhancing the reinjection rate is the important guarantee to implement the sustainable development and utilization of geothermal resources.

Key words: Geothermal resources, the utilization efficiency, reinjection, strategies

1. BACKGROUND

Tianjin Coast New District is the important economic development zone approved by State Council during the eleventh five-year-plan. It lies in north of the North China Plain, locating the belly of Bohai Bay. It includes the Tianjin harbor, Tianjin development zone, Tianjin Port Free Trade Zone and Tanggu, Hangu, Dagang three administrative district and part of area of Dongli, Jinnan, the area is 2,270 km^2 (Figure 1). The district based on Beijing and Tianjin, is the important part of Beijing-Tianjin-Hebei Economic Circle. It has the biggest manmade harbor, the most potential consume market and the most excellent infrastructure. This district locates in the core position of Bohai economic circle. It has the very important strategic position of economy development in north of China.



Figure 1 the location map of Tianjin Coast New District

From the Beginning of development in 1994 to 2005, the district total output value increases about 12.3 times. It shares the specific weight of GDP production value in Tianjin from 23.3% to 42.6%, has already progressively become an accelerator to arouse economy development in Tianjin and the whole around Bohai area. According to the goal of economic development during the eleventh five years plan, the GDP will reach 320 billion Yuan by 2010. Even if the consume of energy decreases 20%, the total amount of consume of energy will reach to32.768 million ton standard coal. Resources becomes the bottleneck of restricting the district economic development, meantime, consumption of general resources give the bigger pressure on environment. Making use of the geothermal resources can mitigate serious demand of energy for economical development, and have very important meaning to constructing the ecosystem environmental protection type of the district.

Tianjin Coast New District enriches plenty of geothermal resources, has 4 geothermal abnormal zones according to he temperature gradient more than 3.5°C/100m (Table 1).

Table 1 the information about abnormal area in Tianjin Coast New District

Geothermal anomaly area	Administrative location	Area (km^2)	The largest geothermal gradient (°C /100m)
Shanlinzi	North-east of downtown, Dongli	315	8.3
Wanjiamatou	Jinnan, west of Dagang	235	8.8
Qiaogu	North of Hangu	90	5.5
Shajingzi	South-east of Dagang	190	4.5
Kancaizhuang	East of Hangu	20	5.5
Total		850	

Tianjin Coast New District geothermal reservoir can be classified as porous reservoir and bedrock fractured reservoir. The top depth of both is 600-1000m and 1500-2000m respectively. At present, most geothermal wells reached to 3400m in depth with temperature of 101 °C. By the end of 2005, three geothermal fields have been explored, including Shanlinzi, Wanjiamatou and Coast. The total exploitable reserve of geothermal fluid is $31.50\times10^6m^3$/yr including porous reservoir $17.62\times10^6m^3$/yr and fractured reservoir $13.88\times10^6m^3$/yr (Table 2).

Table 2 The exploitable reserves of three geothermal fields ($\times10^6m^3$)

Reservoir	Geothermal field	Shanlinzi	Coast	Wanjiamatou	Total
Neogene System porous reservoir	exploitable reserves	6.10	10.44	1.08	17.62
	Reserve degree	C	B+C	D	
	Minghuazhen	3.9065	6.786	0.73	11.4225
	Guantao	2.1935	3.654	0.35	6.1975
Bedrock karst fractured reservoir	exploitable reserves	11.78		2.10	13.88
	Reserve degree	C+D		C	
	Ordovician	3.4162			3.4162
	Cambrian	0.1178			0.1178

2. GEOTHERMAL DEVELOPMENT AND UTILIZATION

2.1 Geothermal Development

The development of geothermal resources in Tianjin Coast New District began from 1970's. By now, there are 109 geothermal wells. Among them 13 wells are reinjection wells. The production is 9.184×10^6 m^3/yr. The amount of reinjection is 191.8×10^3 m^3/yr and 2.09 % of production. Table 3 shows the information about the wells distribution.

Table 3 The information of wells of different reservoir in 2005

Reservoir	Sum of wells	Reinjection wells	Temperature (°C)	Total production ($\times10^6m^3$)	Total reinjection ($\times10^6m^3$)	Rate of reinjection and production (%)
Minghuazhen	23		42-72	1.767	0	0
Guantao	73	3	46-80	6.464	0	0
Ordovician	3	1	72-76	0.33	0	0
Cambrian	1	0	92	0	0	0
Wumishan	19	6	86-100	0.633	0.1918	30.3
Total	109	10			0.1918	2.09

Obviously, ① The main developed geothermal reservoirs are Minghuazhen, Guantao, Wumishan; ② The reinjection wells locate in Ordovician and Wumishan reservoirs. The rate of reinjection and production is less; ③ The amount of reinjection is less. There is serious maladjustment between reinjection and production.

2.2 Geothermal Utilization

The geothermal water is mainly used for heating, bathing, domestic hot water, planting, farming, mineral water bottling, and tourism and so on.

⑴ Heating

40 companies use geothermal water for space heating, the total area is 2.00×10^6 m^2.

⑵ Domestic hot water

There are 700 thousand households used domestic hot water in 2005. It is average 650 thousand person-times every month. The hot water from Minghuazhen reservoir has suitable temperature 42-72°C and good water quality.

⑶ Others

① Geothermal water uses in 11 companies for hot spring entertainment.

② Greenhouse planting in 2 big bases with total area of 30 hectares.

③ Fish farming in 6 companies with total area of 13.34 hectares.

④ Mineral water bottling in 3 companies, the capacity is 17,570 m^3.

The situation of different reservoirs is as follows: ① Minghuazhen reservoir distributed in Dongli. There are 23 wells. The production is 1.767×10^6 m^3/yr. Used for bathing and domestic hot water. ② Guantao reservoir distributed in Tanggu and Dagang. There are 73 wells. The production is 6.464×10^6 m^3/yr used for heating and hot water. ③ Three wells of Ordovician reservoir including one injection well, distributed in Dongli and Jinnan. The discharge is 0.330×10^6 m^3/yr used for heating and bathing. ④ There are 19 wells of Wumishan reservoir including 6 injection wells. They distributed in Dongli, Jinnan and Dagang. The production is 0.633×10^6 m^3/yr, used for heating and domestic hot water.

3. PROBLEMS OF GEOTHERMAL DEVELOPMENT AND UTILIZATION

3.1 Low Efficiency of Geothermal Use

Now the temperature of discharge is about 40 °C, the efficiency of utilization of geothermal energy is 50.75-62.41% (Table 4). The main reasons are: ① the utilization method is simple; the space heating system consumes plenty of resources. ② Technique equipment needs be further optimized. ③ the temperature of discharge is too high which results the low efficiency.

Table 4 The utilization efficiency of different reservoirs in 2005

Reservoir		Discharge temperature (40 °C)
Neogene System porous reservoir	Minghuazhen Fm.	26.19%
	Guantao Fm.	50.75%
Bedrock karst fractured reservoir	Ordovician Sy.	53.04%
	Wumishan Fm.	52.58%

3.2. Low Reinjection Rate

The rate of reinjection is 6.58%, 7.94%, 5.33%, 7.17%, and 7.0% respectively in 2001 to 2005 in Tianjin. While the Coast New District is less than 3%. The imbalance of production and reinjection resulted a decrease of reservoir pressure and formed a regional depression cone. According to monitoring data, the water level in Minghuazhen, Guantao, Ordovician and Wumishan reservoirs decline 2-2.8m, 1.6-5m, 1.6-3m, 2.6-7m in 2002, 2-3m, 2-6m, 2-4m, 3-7m in 2003, 3-5m, 3.21-6.76m, 4-6.91m, 3-8m in 2004, and 3-4m, 2-10m, 5-6.76m, 4.5-9m in 2005. So that, all reservoirs face the faster water level decline if without increase of reinjection.

4. STRATEGIES OF GEOTHERMAL SUSTAINABLE DEVELOPMENT AND UTILIZATION

4.1 Choosing the Suitable Utilization Model

There are five reservoirs with different temperature, flow rate, water quality. The utilization model should be chosen according the character of geothermal reservoir.

① Minghuazhen and Guantao reservoirs: The temperature ranges from 42 to 80 °C. Water quality is good. Water chemical type is HCO_3－Na. TDS is 1-2g/l. It suits for domestic hot water, mineral water, small scale heating must using heat pump and conduct reinjection.

② Ordovician and Cambrian reservoirs: The temperature ranges from 73 to 92 °C. Water chemistry is SO_4－Na·Ca type. TDS is 1-4g/l. It suits for space heating using indirect heating system, if necessary using heating pump to increase the system heat load supply and utilization efficiency. The whole system must be sealed to assure using heat only.

③ Wumishan reservoir: The temperature is 90-100 °C. Water chemistry is $Cl\cdot HCO_3\cdot SO_4$－Na type. TDS is 1.5-1.9g/l. It suits for space heating and integration use. The utilization pattern is exploitation with reinjection (the amount of reinjection is not less than 80% of production).

4.2 Increasing the Utilization Efficiency

Now the discharge temperature is more than 40 °C. If the temperature can be down to 25 °C or 15 °C, the utilization efficiency can be highly increased and can save much of geothermal resources. Table 5 shows the amount of saved resources with different discharge temperature.

The utilization plan of resources is very important to increase the utilization efficiency of geothermal energy. For example geothermal is used for basic heat load in space heating design which will greatly increase the utilization efficiency, to choose stepped and integrated utilization pattern in technique, using heat pump technique to take more heat to decrease the discharge temperature, end-equipment should use radiant heating technology and air-blower tube technology. In sum, it is systematic engineering to increase geothermal utilization; we should establish the technique criterion and optimize the plan and strict censor the design.

Table 5 The amount of saved resources with different discharge temperature

Reservoir	Production of 2005 ($\times 10^6 m^3$)	Discharge temperature 25 °C		Discharge temperature 15 °C	
		Thermal utilization efficiency	Amount of saved resources	Thermal utilization efficiency	Amount of saved resources
Minghuazhen	1.767	65.73%	55.93%	92.09%	67.8%
Guantao	6.464	77.13%	40.55%	94.72%	52.99%
Ordovician	0.330	73.56%	48.12%	93.88%	60.57%
Wumishan	0.633	82.32%	25.39%	95.92%	35.80%

4.3 Increasing the Reinjection Rate

The results of exploration show that the heat storing in rock and unexploited geothermal fluid is the 99.5% of total geothermal resources. Reinjection is the only way for the geothermal resources renewable. Tianjin began the reinjection test early. But up to now the reinjection rate is less than 8%. The main reason is that the ration of reinjection well and production well is serious low (13:235). The production and reinjection is imbalance. Adding the reinjection wells and the amount of reinjection is guarantee of realizing sustainable development and utilization of geothermal resources.

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