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Utilization State and Protection Project in Tianjin Geothermal Area

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ABSTRACT

This report is based on exploitation and utilization data of geothermal resources in Tianjin, and is aimed at the existing problems such as the lack of a unified plan, low utilization ratios and low reinjection ratios. Several counter measures are put forward, which include subarea management, gross control, intensity control, utilization mode control and distribution optimization. According to the measures, the geothermal area is divided into 4 types: confined exploitation zone, controlled exploitation zone, encouraged exploitation zone and exploring zone. Then some respective protective aims and measures are carried out for the sustained exploitation and utilization of geothermal resources.

1. GEOTHERMAL RESOURCES SITUATION

The North China rifted-basin contains rich geothermal resources under the ground. The City of Tianjin is located in the northern part of the North China rifted-basin and is a Chinese economic centre, having an extremely important strategic position in our country's economic growth. But the City of Tianjin is somewhat short in natural resources, which is restricting the development of the Tianjin economy. Geothermal resources are one kind of energy generation that may be possible; it is hoped that geothermal resource exploitation and utilization can relieve Tianjin's strained situation, promoting economic development.

Throughout the Tianjin area geothermal resources general investigation it can be seen geothermal resources are distributed in an area to the south of Tianjin Ninghe-Baodi fracture, amounting to 8700 km^2. According to an average geothermal gradient of caprock greater than 3.5 ℃/100 ms partition, ten geothermal abnormal areas have been fixed, and the middle-low temperature geothermal resources appear to be considerable [1]. These are expressed in Table1 as well as in Figure.1 and Figure.2.

According to existing layer and characteristic dividing, Tianjin geothermal reservoirs include sandstone porous reservoirs and fracture-karst reservoir, and their roof depths are roughly 500□2000m and 1000□1500m . At present, Tianjin geothermal exploration to a depth of 4041m is already underway, the fluid of well mouth temperature is mostly around 117℃. By the end of 2008, there had already been prospecting and estimating of six big geothermal fields, which have been attested by country reserves set: geothermal field of Wang Lanzhuang, Shan Lingzi, Binhai new area, Wanjiamatou, Pan Zhuang-Lutai, Ninghe-Hangu and Yang village of Wu Qing. According to regulation (the geothermal resources geology prospecting standard), 25℃ geothermal water is the geothermal resources the lowest temperature [3], then above-mentioned seven geothermal fields with geothermal fluid exploitable reserves amounting for 5997×104 m^3/a, among them, Neogene sandstone porosity reservoir geothermal fluid exploitable reserves measuring 3983×104 m^3/a, and bedrock fracture-karst reservoir of geothermal fluid exploitable reserves amounting to 2014×104m^3/a.

2. EXPLOITATION AND UTILIZATION SITUATION

Last century in the 70's, under the famous geologist and Professor Li Siguang, Tianjin began to exploit geothermal resources on a large scale. To date formed a geothermal resources city with most highly studying degree, maximal exploitation and utilization scale. At present Tianjin geothermal resources exploitation and utilization is mainly in the downtown areas of Tanggu , Dagang and Wuqing.

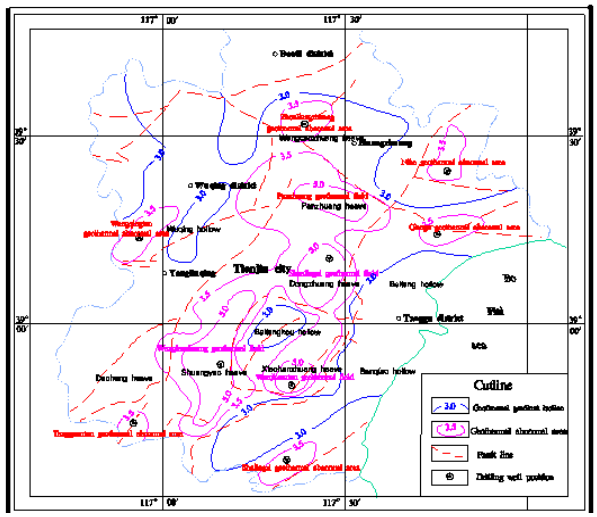

Figure 1: Distribution of geothermal abnormal area in Tianjin

2.1 Geothermal Well General Situation

According to statistics ending in 2008, Tianjin has 318 geothermal wells, including 42 reinjection wells. Geothermal fluid exploitable reserves amount to 26,040,000 m^3 per year, reinjection amounts total 5,860,000 m^3, or 22.5% of exploitable reserves[4]. Geothermal well distribution in every reservoir is shown in T\able 2.

2.2 Geothermal Fluid Utilization Situation

The City of Tianjin geothermal fluid is mainly used to supply heating: providing familes with hot water for cultivation, heating, bathing, and entertainment as shown in Fig.3.

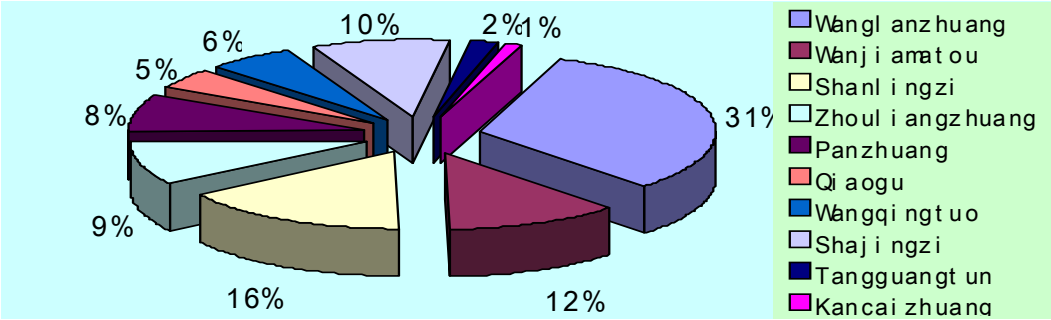

Figure 2: Proportion of geothermal abnormal area in Tianjin

Table 1. Data Sheet of Tianjin Geothermal Abnormal Area.

Geothermal abnormal area	Structure location	Administrative area location	Area (km^2)	Max geothermal gradient of caprock (℃/100m)
WangLanzhuang	Shuangyao heave	southeast central	534	8.0
Shan Lingzi	Dongzhuang heave	Northeast central, Dongli	315	8.3
Wanjiamatou	Xiaohanzhuang heave	Jinnan and west Dagang	235	8.8
Pan Zhuang	Panzhuang heave	west Ninghe district	610	6.9
ZhouLiangzhuang Zhuang	Wangchaozhuang heave	Southeast Baodi district	180	5.5
Qiao Gu	Tectonic strip	North Hangu District	90	5.5
Wang Qingtuo	Dacheng heave	Southwest Wuqing district	114	5.0
Sha Jingzi	Beidagang heave	Southeast Dagang district	190	4.5
Tang Guantun	Tectonic strip	South Jinghai district	40	7.6
Kan Caizhuang	Tectonic strip	east Hangu District	20	5.5
Total			2328	

Table 2. Data Sheet of Geothermal Wells Distribution in 2008.

Reservoirs	Wells sum	Reinjection wells quantity	Temperature range (℃)	Exploitable reserves sum (10^4m^3)	Reinjection Sum (10^4m^3)	Reinjection quantity/ exploitable reserves(%)
N_m	79	2	42 ~ 72	390.0	13.4	3.4
N_g	108	6	46 ~ 80	811.0	9.7	1.2
Ed	3	0	74 ~ 91	8.0	0	0
O	12	1	53 ~ 78	103.0	143.0	138.8
€	5	0	68 ~ 92	22.0	2.5	11.4
J_{xw}	101	24	75 ~ 117	1250	417.4	33.4
CHg	1	0	0	20.0	0	0
Total	318	42		2604.0	586.0	22.5

Obviously□□Major objective tier of geothermal development are N_m□N_g and J_{xw} in Tianjin□□Reinjection wells mainly distributes in O and J_{xw} ,and Reinjection wells Proportion is small□□ Reinjection sum is small , and proportion of exploitable reserves and reinjection quantity loses balance.

Table 3. Thermal Utilization Factor of Each Geothermal Reservoir in Different Discharge Temperature in 2008.

Reservoirs	Tail water discharging temperature		
	40□	25□	15□
Nm	26.19%	65.73%	92.09%
Ng	50.75%	77.13%	94.72%
O	43.04%	73.56%	93.88%
Є	62.41%	82.55%	95.97%
Jxw	57.58%	82.32%	95.92%

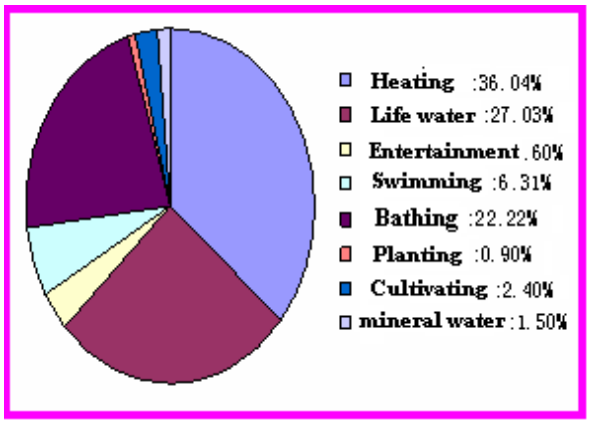

Figure 3: Tianjin Geothermal utilization field distribution situation

2.2.1 Heating

At present, the City of Tianjin has 180 units to make use of geothermal water for residential heating, maximal city heating supply covering an area of 12,600,000 m^2 , making it our largest geothermally heated city, expressed by Fig.4.

2.2.2 Life Water

According to statistics for 2008, the whole city has 100,000 residents of family to use life hot water, about 850,000 makes use of field hot water to take bath every year. This is because the N_m reservoir geothermal water temperature is between 42degC~72degC, with a mean temperature of 52.13degC, and fine water quality. Therefore residents take baths mainly using the N_m reservoir geothermal water.

2.2.3 Other Aspects

□The geothermal water 21 units are developed and use for the water for hot spring entertainment.

□3 more large-scale cultivating bases use the geothermal water to carry out agriculture, amounting to 508.9 mus.

□7 units make use of geothermal fluid to carry out aquaculture, amounting to 243.16 mus.

□6 units make use of geothermal water to produce mineral water.

□16 the unit uses geothermal water to cleanse, commercial runs such as printing and dyeing , air-conditioning is listed

2.3: Exploitation and Utilization Problem

2.3.1 Geothermal Exploitation is Short of the Unified Plan

The current geothermal fluid exploitation and utilization continues the traditional pattern that has existed for a long time. However, short of a strong geothermal exploitation and operations plan, it will not be possible to realize geothermal waters potential benefit to the economic growth of Tianjin. Due to the current lack of coordination or unified plan, geothermal life water supply and running water supply exist in a certain competition, and it is also difficult to interface geothermal heating and the city central heating.

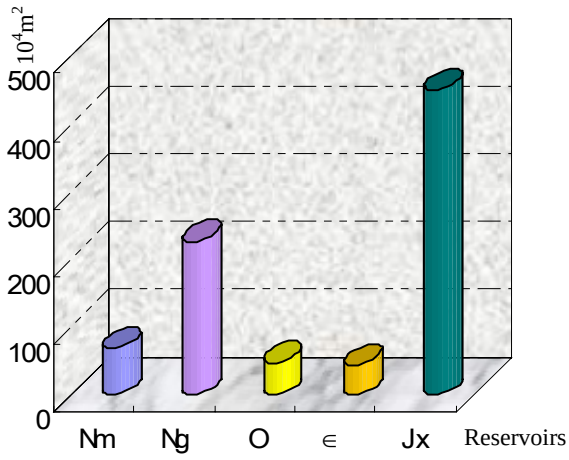

Figure 4: Heating area of reservoirs

2.3: Exploitation and Utilization Problem

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2.3.2 Geothermal Utilization Ratio Low

Since water temperature, flow rate, and water quality of each reservoir is different, the geothermal utilization ratio of each reservoir is also different. The heat utilization efficiency that is listed in Table 3 shows the temperature of

the geothermal tail water discharged is 40 degC, 25 degC and 15 degC respectively. Evidently, the lower the temperature of the geothermal tail blowoff water, the higher the heat utilization ratio.

According to statistics in 2008, geothermal heating ratio of Nm, Ng, O, € and Jxw reservoirs are 18.04□, 44.44□, 27.93□, 48.52□, and 63.66□ respectively, as shown in Table 3. .Because the water temperature of Jxw, € and Ng is higher and their relative utilization temperature difference is high, their geothermal utilization ratio is higher than Nm and O.

The main cause of the low geothermal utilization ratio is the utilization structure. The geothermal heating system consumes large amounts of fluid, discharging after minimal use. The utilization technology, handicraft and assorting equipment need to be optimized further. At present the geothermal utilization system, especially the historic system cannot extract the potential of the geothermal water effectively. Geothermal tail water that is discharged at high temperature has not only led to a low geothermal utilization ratio, but also to thermal pollution.

Improving geothermal water utilization ratio can reduce the amount of geothermal water required, reaching low yield high-effeciency targets. Table 4 expresses that when lower temperatures of geothermal tail water ar discharged, the utilization of geothermal water resource improved the percentage exploitation in 2008.

Table 4. The Proportion of Saving Energy in Different Discharge Temperature in 2008.

reservoirs	25℃	15℃
Nm	55.93%	67.8%
Ng	40.55%	52.99%
O	48.12%	60.57%
€	27.04%	37.81%
Jxw	25.39%	35.80%

2.3.3 Reinjection Ratio Low

Geothermal reinjection ratios of Tianjin are 15.8% , 22.5% respectively in 2007 and 2008, as shown in Fig.5. Since increasing reinjection year by year, the reinjection ratio is now higher, but continues to be far below what is required. The persistent imbalance between exploitation and reinjection has caused a drawdown of the geothermal reservoir water level down gravely, forming a lowere water level funnel area. Experimental evidence acquired from, Nm ,NgO and Jxw of Tianjin, in 2008, geothermal water level drawdown extent are approximately 1.4□4.2m, 1.5□5.0m, 1.40□3.05m, 3□15m respectively.

Hence, if flows to reinjection wells are not increased, each reservoir will be confronted with the problem of serious water level decline.

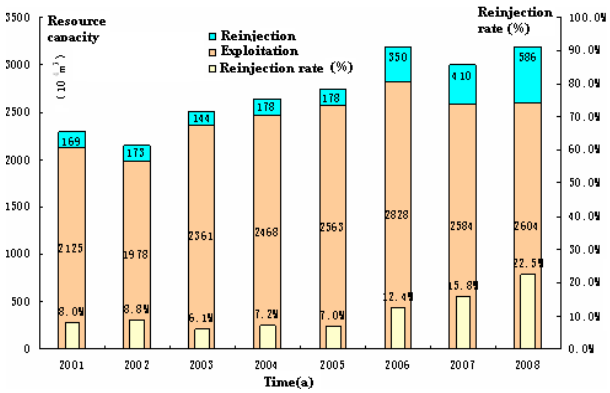

Figure 5: Statistical chart of geothermal resource exploitation amount, reinjection amount and reinjection ratio in Tianjin

3. GEOTHERMAL RESOURCE PROTECTION PRINCIPLE

3.1 Managing in Subarea

According to exploitation amount, the water level depth, and water level declining ratio, each geothermal reservoir is managed by subarea.

Water level equivalence line and the water level declining ratio equivalence line are directly from reports of geothermal resources and resources consumption trends, and provide a scientific, effective approach to resolving conflicts between community requirements and efficient resource management . That carrying out a subarea plan according to this is objective, scientific, intuitive, realistic, and can hopefully make planning more straightforward.

3.2 Exploitation Sum Control

The exploitation sum control principle refers to the principle that for the same reservoir, the sum of planned geothermal well exploitation and the existing geothermal well exploitation should not be more than the exploitable reserves of the reservoir.

3.3 Exploitation Strength Control

Strength controlled exploitation is that, according to each subarea, controlled measures for regulating water level can decrease rate of flow required by this subarea.

On the premise of satisfying total control, according to whether different heat utilization of geothermal reservoir partitions is consistent with the control conditions of this areas exploitation strength, which is strength and sum double control conditions.

3.4 Utilization Patterns Control

According to various heat reservoirs resource types and characteristics, determine the relative suitable utilization patterns, especially on new development project of geothermal resources should carry out feasibility analysis of development and utilization

3.5 Optimization Configuration

Geothermal resources allocation should follow the following principles: the strategic project priority configuration, an important project to guarantee configuration, and general project control configuration.

Through scientifically deploying geothermal resources, insist on science and technology innovation to improve the level of geothermal resources comprehensive utilization.

4. PROTECTION MEASURES

According to the resources, set up different types of exploitation zones. A different zone should be taken on various policy measures, implementation of the exploitation under protection and the protection under the exploitation, scientific, rational and sustainable exploitation and utilization of geothermal resources.

5. PROTECTION GOAL

5.1 Increase Heat Utilization

For different reservoirs of geothermal resources, make scientific and rational utilization of the scheme, in the structural adjustment of geothermal resource utilization, change the pattern single utilization of geothermal, especially single geothermal heating use pattern, actively promote the cascade development and utilization of geothermal resources pattern, reduce geothermal resource exploitation , and improve the heat utilization ratio.

5.2 Improve Reinjection Ratio

Reinjection is an important metric for the realization of sustainable development and utilization of geothermal resources; increasing reinjection wells is an important means to improve the reinjection rate; increase different amount of reinjection wells for various reservoirs. Across the whole city, actively promote the geothermal reinjection development model to improve the reinjection rate.

5.3 Renovation of Geothermal Utilization System

To the extent that there are unreasonable, non - canonical problems to some traditional geothermal station, you must have a plan to carry out renovation, and make the necessary reform of these mandatory with policy and technical support, particularly where the geothermal utilization systems are wasting serious resources.

5.4 Build Dynamical Monitoring Network

At present, the geothermal wells dynamic monitoring network of Tianjin have some problems, such as unbalanced, incomprehensive and unstable . The data acquisition means is original, inefficient and subject to external factors, which does not meet the need of resource assessment and planning. So the dynamic monitoring network layout adjustments and construction should be given high importance.

5.5 Construct the Typical Project

Development and utilization of geothermal resources refers to many areas, especially some new technologies and new techniques being explored. It is an area underdevelopment, and of great importance for a typical project. We must select different reservoir types to enlarge the use field, establish intensive utilization models of projections of tourism, agriculture ,medical spring water, and so on. In the management process, the typical project is to model, promote, and apply technology for typical projects to improve how comprehensive they are.

5.6 Increase the Strength of Geothermal Resources Exploration

Judged by "the City of Tianjin mineral resources requirement of the overall planning", strengthening geothermal resources should involve prospecting for blank area and blank tier of Tianjin. A more complete study of the science to furtherrestricting exploitable area, control exploiting area, and encourage development in the exploiting area.

5.7 Ascertain Protection of Ecological Environment

Development and utilization of geothermal water might lead to environmental problems of salinization, thermal pollution and land subsidence, etc.

5.7.1 Salinization

Some region of Tianjin with higher salinity (4 -5 g/l) of Ordovician geothermal water, in other region, geothermal water salinity is about 2g/L. Therefore, excluding Ordovician geothermal water, geothermal resource exploitation and utilization should not lead to salinization problems in Tianjin. For higher salinity Ordovician geothermal water, we may take reinjection measures to avoid the environmental impacts on the soil.

5.7.2 Geothermal Pollution

Our country's definition of standard thermal pollution is 35 °C, at present, geothermal water emissions exceed 35 °C in Tianjin, therefore constituting thermal pollution. There are two solutions: one is using radiant floor heating, or heat pumps, and so on, using new technologies to improve geothermal utilization technology, reducing the emission of temperature; the other one is by using more reinjection, and therefore not discharging into the environment.

5.7.3 Ground Subsidence

Existing research findings show that exploitation of geothermal water of depth of less than 600m can cause ground subsidence, and that exploitation of depth of more than 600m in tertiary geothermal reservoirs and bedrock geothermal reservoirs normally has not caused ground subsidence. Always, maintaining reservoir pressure through reinjection, is crucial to slow down surface subsidence.

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