*Proceedings World Geothermal Congress 2000*
*Kyushu - Tohoku, Japan, May 28 - June 10, 2000*

# ROLE OF THE GOVERNMENT IN DEVELOPMENT AND MANAGEMENT OF GEOTHERMAL ENERGY IN TIANJIN OF CHINA

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**Key Words:**
Government Management Geothermal

**ABSTRACT**

Tianjin is the first city of exploration geothermal. It is located in the north part of China. The geothermal exploration is started in 1970's. Nine geothermal anomalous areas have been delineated. Since 1990's, the use of hot water have been changed for space heating which is from basement reservoir at the depth 2000-4000m. As the 'Geothermal resource appraiseate method', 'Geologic exploration standard of geothermal resource' and 'The Regulation of geothermal Resource Management in Tianjin' have been carried out, geothermal development have been made into logal institutionalize.

**Introduction**

Tianjin is situated in North part of China, at longitude 117°E, latitude 39°N. It has an area of 11305 km$^2$, and most of it is plain.

Due to Tianjin's location on the north China platform, the geothermal gradient is higher to 3.5-8.8$^o$C/100m. It is covered with Quaternary and Tertiary system except mountain regions in Tianjin. The thickness is about 100-9000m. It is Ordovician, Cambrian and Precambrian formation under the Tertiary systems which are main basement geothermal reservoirs. Nine geothermal anomalous areas have been found and comprehensive researched. Two geothermal fields – Wanglanzhuang and Shanlingzhi have been explored.

During the development of Tianjin's geothermal energy, governmental function has been playing an active role in guiding, promoting and regulating the scientific management of the energy.The development of the geothermal energy in Tianjin falls in four stages.

**Geothermal Exploration**

The stage of preliminary exploration, extraction is stimulated. In 1970s, the exploration in Tianjin had just started and was going on while exploration. Since the reserve was not found, the government gave the financial support to the exploration. Few enterprises and individuals invested in drilling hot wells because of the risk. The wells were drilled and placed in favorite sites by the exploration company and used by local people free of charge. The purpose of this was to make people know the new geothermal energy by using it to lay a foundation for future development.

By the end of 1970s, The distribution, depth, type and total reserves of Tertiary geothermal resource have been established, and developed in large scale. It is covered with Cenozoic grope except mountain regions in Tianjin. The thickness is 100 – 400m in the north part of Baodi fault, 1000 – 2000m in uplift of south part of the fault and 8000 – 9000m in depression (figure.1). Immense amount of geothermal water in Tertiary reservoir is come from sandstone formation. The Area that Tertiary system covered is 9000km$^2$. Nine geothermal anomalous areas have been delineated that take the geothermal gradient of 3.5$^o$C/100m as the Geologic exploration standard of geothermal resource, which cover the areas 2320km$^2$. Figure 1 shows main tectonic and nine geothermal anomalous areas. The highest geothermal gradient is 8.8$^o$C/100m in the center of the anomalous areas. Table 1 shows the basic data of geothermal anomalous areas.

The booming stage of geothermal development and utilization is in 1980s. The first basement geothermal well has been drilled in July 1979 that is pioneer of basement geothermal development in China. The exploration of Wanglanzhuang and Shanlingzhi geothermal fields were accomplished and the distribution and reservoir of geothermal energy was also identified to a certain

degree. The users got to know the advantages of the energy during the stage when preferential policy was implemented, so the demand to the energy was getting greater.

Table 2 shows the geothermal resource of Wanglanzhuang geothermal field

Table 3 shows the geothermal resource of Shanlingzhi geothermal field

It is widely used in industrial, textile, wood processing 73%, bathing 26% and agriculture 1%. Especially the economic benefit in industrial is remarkable (Figure 2 ).

**Geothermal development made into a legal institutionalize**

The stage of setting up special management agency and laying down regulation. In 1990s, the amount of geothermal wells is getting more and more as the scale of geothermal development is getting large. The purpose of geothermal development change from industry to heating and bathing as the living standard higher and higher. The temperature of the water is very important. The numbers of basement well increase every year. Hot water comes mostly from basement reservoir. The aquifer temperature is 70-100$^{o}$C. The area of geothermal heating is 4500000m$^{2.}$ Production of hot water is 4870000m$^{3}$, heating 83%, bath 15%, and fishing 2% (Figure 3 ). Many problems appear in the management of geothermal energy, such as the too rapid increasing of wells, the unreasonable placing of the wells, and the planless extraction. In 1994, Tianjin municipal government decided to set up Tianjin Geothermal Management Section on the basis of detailed investigation and demonstration and "The Regulation of Geothermal Resource Management in Tianjin" was issued in the same year. The regulation defined the main responsibilities of the geothermal management section which are as follows. (1) managing the exploration, development, utilization and conservation of geothermal resource, (2) making plans for geothermal development and utilization, (3) examining and approving the drilling of geothermal well, checking and ratifying extraction quota and issuing licence of geothermal extraction, (4)
imposing geothermal resource fee, and (5) managing projects of geothermal research and test. The 7$^{th}$ item of the regulation stipulates that licence is required for geothermal extraction. The procedure is : (1) making the application, (2) feasibility demonstration, and (3) examing and approving the application.

Geothermal energy is owed by the state, those who extracting geothermal water need to pay the geothermal resource fee to the state. The fee is charged according to the temperature of the water. The money is used mainly for the management, conservation, research and test of geothermal resource. Each well has to set the flowmeter to collect the data.

The stage of management according to the regulation and make comprehensive utilization. After legislative work, the management of geothermal development got onto the legal track. The governmental function played an important role in promoting the comprehensive use of geothermal energy. Comprehensive use is regarded as a prerequisite is the process of examining and approving the application of drilling geothermal wells, so that the users have to make full use of the energy and exploiting the water in a grading way, using the water for different purposes according to its temperature. The work of well rejection also started with the support of the government. At the beginning, the government gave money to carry out rejection test in geothermal reservoirs of different type.

Four injection experiments have been carried out in Tianjin. Table 4 shows the basic information of the four injection experiment The first injection experiment has been carried out during 1982 – 1986 in Tertiary reservoir of Wanglanzhuang geothermal field in Tianjin.

The injection experiment of Dagang district was carried out in Tertiary reservoir during 1987 – 1990 with two types: a), well 2 and well 5 are production wells where locate about 100-150m from injection wells R2 and R12. The injection water is from depth 700m 37$^{o}$C and 1370m 55$^{o}$C. b, The waste water from heating system are used in injection experiment. The production well R2 located about 1820m from injection well R12. Table 5 is the basic information of the injection experiment. The injection experiment of Tanggu was carried out during 1992-1996. During the experiment hot water is from Tertiary system

reservoir for space heating, the wasted water from heating system was used for injection. The production well TR5 locates 650m from injection well TR91. Table 6 is the basic information of the injection experiment.

The experiment of Wanglanzhuang geothermal field is carried out during 1996-2000. During the experiment 70$^{o}$C waste water from heating system is injected into the injection well, Which the depth is 1600m. At first the injection rate is 100m$^3$/h with the lower water head pressure, and later the injection rate at 70-80m$^3$/h. Total amount of injection is 270129m$^3$, last 5 month. Concurrently the water level in nearby wells is monitored carefully. Chemical tracers test are going to be employed during the winter 1998.

After experience had been gained, the policy of examining and approving applications was adjusted to facilitate rejection. For example, reinjection must be carried where conditions permit. The users who carry out reinjection enjoy a preferential treatment of reducing geothermal resource fee.

**Conclusions**

It can be seen from the history of geothermal development in Tianjin, the role of the government cannot be substituted by others during the process of development. It is the basis for scientific management of geothermal resource.

1.In the initial stage, the reserve was not found, the government gave the financial support to the exploration. its encouraging policy makes the people know the energy and its advantage.
2. In the second stage, it lets the user see the economic benefit brought by geothermal energy, laying a wide foundation for further development.
3. In the stage of legislative work, it brings the management to the legal track so that the level of management get raised.
4. In the stage of scientific management, it assures the sustainable development of the geothermal development under the legal institution.

**Acknowledgements**

The author would like to thank for the staff of Geothermal research Institute working during the geothermal exploration and allowing publication of the data. We also thank the supporting of Tianjin Geothermal Management Section for prepareing the paper.

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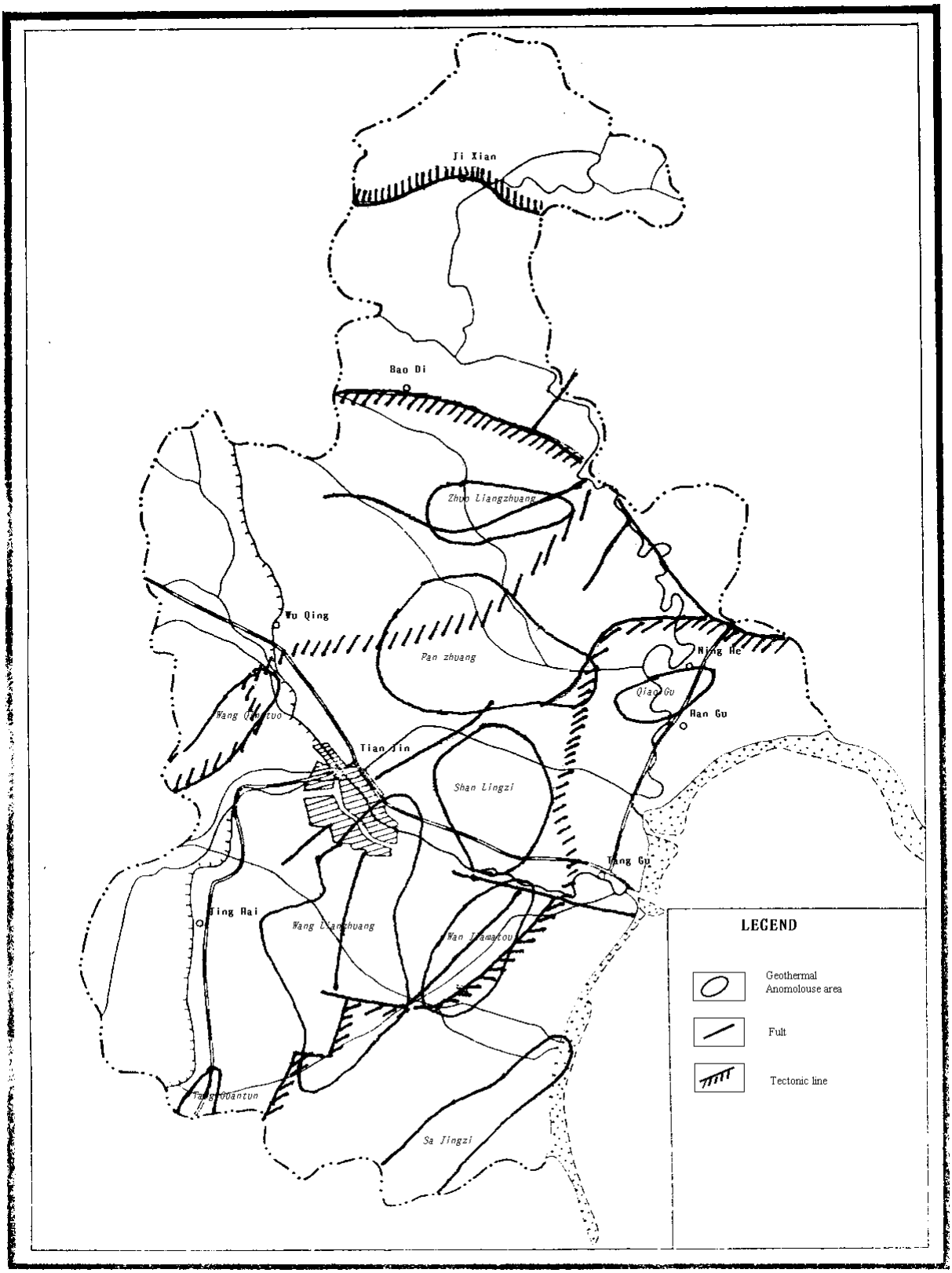


Figure 1 Main tectonic and nine geothermal anomalous areas of Tianjin

Table1. Basic data of geothermal anomalous areas

| Place | Depth (m) | Areas ($km^2$) | Gradient ($^oC$/100m) | Resource ($10^{18}J$) |
|---|---|---|---|---|
| Wanglanzhuang | 400-1500 | 640 | 8.0 | 20.88 |
| Shanlingzhi | 400-2500 | 315 | 8.3 | 10.07 |
| Wanjiamatou | 400-1500 | 235 | 8.8 | 5.42 |
| Zhouliangzhuang | 500-2700 | 180 | 5.5 | 4.66 |
| Panzhuang | 450-2800 | 610 | 6.9 | 23.8 |
| Qiaogu | 500-3000 | 110 | 5.5 | 5.99 |
| Shajingzhi | 470-2800 | 190 | 4.5 | 9.17 |
| Wangqingtuo | 470-3000 | 114 | 5.0 | 4.17 |
| Tangguantun | 500-1100 | 40 | 7.6 | 0.52 |
| Total | | 2320 | | |

Table 2 Geothermal resource of Wanglanzhuang geothermal field

| | | Geothermal resource | | | Hot water resource | | |
|---|---|---|---|---|---|---|---|
| | | $10^{18}J$ | $10^{14}Kkal$ | $10^{10}Kwh$ | Total $10^8 m^3$ | Drawdown 110m($10^6m^3$) | Drawdown 150m($10^6m^3$) |
| Tertiary | 1002 (km2) | 20.88 | 49.89 | 580.14 | 503.15 | 643.16 | 979.95 |
| | 640 (km2) | 13.81 | 32.99 | 383.60 | 236.25 | 325.82 | 535.75 |
| Basement | 2000 (m) | 18.92 | 45.19 | 525.54 | 35.07 | | |
| | 3000 (m) | 45.79 | 109.36 | 1271.86 | 46.19 | | |

Table 3 The geothermal resource of Shanlingzhi geothermal field

| | | Geothermal resource | | | Hot water resource |
|---|---|---|---|---|---|
| | | $10^{18}J$ | $10^{14}Kkal$ | $10^{10}Kwh$ | Drawdown 100m($10^6m^3$) |
| Tertiary | | 34.50 | 82.40 | 958.00 | 601.10 |
| Basemen | 2000 (m) | 48.98 | 117.00 | 1361.00 | 266.00 |
| | 3000 (m) | 106.14 | 253.50 | 2948.00 | 912.13 |

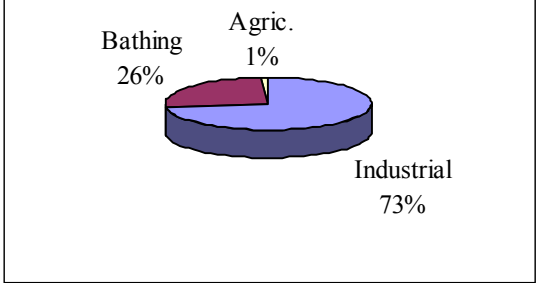


Figure 2 Use of hot water from Tertiary reservoir

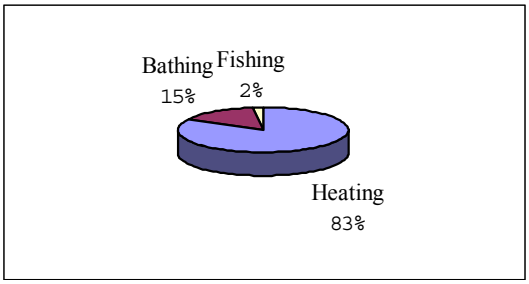


Figure 3 Use of hot water from bedrock reservoir

Table 4. Basic information of the four injection experiment.

| Time | Place | Reservoir | Depth(m) |
|---|---|---|---|
| 1982-1986 | Wanglanzguang | Tertiary system | 500-700 |
| 1987-1990 | Dagang | Tertiary system | 1700-2000 |
| 1992-1996 | Tanggu | Tertiary system | 1700-2000 |
| 1996-2000 | Wanglanzhuang | Precambrian system | 1700-2000 |

Table 5 Basic information of the injection experiment in Dagang

| Date | Time (day) | Injection well | Amount of injection ($m^3$) | Temp of injection ($^oC$) | Production well | Distance (m) |
|---|---|---|---|---|---|---|
| 1987.7.23-9.15 | 54 | R2 | 23000 | 55 | 5 | 150 |
| 1987.11.11-11.27 | 16 | R12 | 8889 | 38 | R2 | 1820 |
| 1988.5.14-7.21 | 68 | R12 | 23819 | 37 | 2 | 100 |
| 1988.8.9-9.9 | 31 | R12 | 9867 | 37 | 2 | 100 |
| 1989.8.31-9.5 | 6 | R12 | 2465 | 37 | R2 | 1820 |
| 1989.9.10-9.25 | 15 | R12 | 12503 | 37 | R2 | 1820 |
| 1989.10.6-10.12 | 7 | R12 | 7400 | 32.5 | R2 | 1820 |

Table 6 Basic information of the Tanggu injection experiment.

| Date | Time (day) | Amount of injection ( $M^3$) | Injection rate ($M^3$/h) | Pressure (Mpa) |
|---|---|---|---|---|
| 1995.12.18—1996.3.6 | 79 | 12332 | 46.90 | 0.50 |
| 1996.2.5-2.12 | 7 | 7931 | 45.26 | 0.50 |
| 1996.3.1-3.2 | 1 | 927 | 84.00 | 0.78 |