

“China Geothermal Town” Construction Promote Geothermal Development in China-Xianyang Model and Xiongxin Model as Two Examples

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ABSTRACT

Geothermal resources are important in the renewable energy field and its exploitation is currently becoming more popular. The “China Geothermal Town” naming action is helpful for regulating geothermal exploitation behavior directed by the MLR and the CMA. Two examples, Xianyang Geothermal City and Xiongxin Geothermal Town, are successful models for the promotion of geothermal development.

1. BACKGROUND

Energy shortages and CO₂ emissions are two serious problems that China has been facing in recent years. Renewable energy use is becoming more popular due to governmental encouragement. Geothermal resources are an important part of the renewable energy field and its exploitation is rising rapidly all over the country. Strong social requirements and the appearance of some problems create a need for management and regulation. In order to promote rational development, sustainable utilization, strict management, and the available protection of geothermal resources, the Ministry of Land & Resources of the People's Republic of China (MLR) and the China Mineral Association (CMA) cooperatively established the “China Geothermal Town” naming action domestically in 2004.

2. INTRODUCTION

2.1 Conditions of Naming a “China Geothermal Town”

The phrase “Geothermal Town” does not necessarily indicate an administrative town or city, but instead designates those areas with rich geothermal distribution, active development, outstanding achievement, and modelling functionality of utilization technology and local industry economy. To get the name of “China Geothermal Town”, an area must meet the following conditions: 1) a detailed geothermal field prospecting report; 2) a large-scale geothermal field in the area (i.e. production energy > 50MW or mining fluid > 10000 m³/d); 3) temperature of geothermal fluid > 40°C; 4) sufficient use of geothermal resources, advanced technique, obvious economic, environmental, and social benefits, forms special geothermal culture, and an importance of geothermal industry in the local economy; 5) a comprehensive scheme for the strict management of waste discharge to prevent pollution; and 6) dynamic monitoring system for water level, temperature, and fluid quantity and quality.

2.2 Procedures of Application and Approval of Naming “China Geothermal Town”

Those areas interested in receiving the name of “China Geothermal Town” must follow the following procedures:

1) The local government as the applicant must submit the application to its provincial department of land & resources, and the MLR and CMA must receive a recommendation from the provincial department of land & resources and the provincial mineral association. 2) The MLR and CMA organize a group of experts for overall field examination and evaluation. 3) After more than 2/3 of members of the evaluation committee reach a positive agreement, the MLR will designate the area to officially be a “China Geothermal Town”.

2.3 Achievements of Naming “China Geothermal Town” during 5 Years

Over the last 5 years, the MLR and the CMA have approved 23 “China Geothermal Towns” or “China Geothermal Cities” and model areas in 15 provinces. Most of them have shown huge economic, social, and environmental benefits through their construction. Also, most have had strong effects on geothermal modelling, prospecting, and utilization in China. A list of China Geothermal Towns, Cities, and Model Areas is given in Table 1.

Two specific examples are introduced as models in this paper: Xianyang China Geothermal City and Xiongxin China Geothermal Town.

3. XIANYANG MODEL

Xianyang City is located in the middle of the Guanzhong Basin in northwestern China, which belongs to the Shanxi Province. Its total land area is 10,119 km², and its population is 4.869 million, with 0.52 million in the urban area. Xianyang is a famous historical cultural city in northwestern China and is located very close to Xi'an City, the Capital of the Shanxi Province. The economy of Xianyang is quite a bit smaller than that of Xi'an City, and the latter affects the former. Geothermal resources are quite abundant in Xianyang. Its reservoir spans 3000 km², and prospecting fluid reserves reach 345 billion m³. Since the first well was drilled in 1993, 40 wells have been drilled in Xianyang with depths ranging from 1500 – 3500 m, temperature ranging from 60 – 130°C, and well production ranging from 55.34 – 350 m³/h. 90% of these wells are still artesian wells. The main use for geothermal energy was house heating in winter, but the resource is starting to be used more comprehensively.

From 1993 to 2005, 23 geothermal wells were drilled by separate companies and owners in Xianyang City, mainly for house heating purposes in winter. The total heating area was 1 million m² at that time, and annual production was about 2 million m³. A simple geological reserve estimate of 37.3 billion m³ for 177 km² in the urban area was realized in 1995. Geothermal demand and development were urgent and rapid in this place, but geoscientific work and governmental management were lacking.

Table 1: List of China Geothermal Town (City and Model Area)

No	Named Place	Expert Evaluation Time	MLR Issue Time	Given name
1	En'ping, Guangdong	2003.3.20	2003.3.21	China Geothermal Town
2	Lindian, Heilongjiang	2004.6.19	2004.6.23	
3	Qionghai, Hainan	2005.8.10	2005.8.30	
4	Xiaotangshan, Beijing	2005.10.21	2005.11.01	
5	Chenzhou, Hunan	2005.10.28	2005.11.01	
6	Qingyuan ,Guangdong	2006.01.06	2006.01.17	
7	Xianyang ,Shanxi	2006.02.18	2006.02.27	China Geothermal City
8	Xiongxin, Hebei	2006.03.7	2006.03.10	China Geothermal Town
9	Xianning, Hubei	2006.09.19	2006.09.26	
10	Weihai ,Shandong	2006.12.08	2006.12.22	
11	Tangchi ,Yingcheng	2006.12.18	2006.12.28	Model Area
12	Ba'nan, Chongqing	2007.10.18	2007.10.25	China Geothermal Town
13	Bazhou, Hebei	2007.11.28	2007.12.20	Model Area
14	Gu'an, Hebei	2007.12.12	2007.12.25	
15	Lianyungang ,Jiangsu	2007.12.16	2007.12.28	
16	Nanjing, Jiangsu	2008.01.08	2008.01.18	
17	Yangjiang, Guangdong	2008.01.18	2008.01.25	China Geothermal Town
18	Lintong ,Shanxi	2008.04.29	2008.05.07	China Royal Hot Spring Capital
19	Yongtai, Fujian	2008.05.10	2008.05.20	China Geothermal Town
20	Lianjiang, Fujian	2008.06.28	2008.07.10	China Geothermal Town
21	Linyi, Shandong	2008.07.26	2008.08.08	China Geothermal City
22	Dongli ,Tianjin	2008.12.13	2008.12.25	China Geothermal Town
23	Shiqian, Guizhou	2008.12.21	2009.1	China Geothermal Town

In order to change the old utilization style, improve the geothermal utilization level, and manage geothermal exploitation activity in an orderly fashion, the Xianyang municipality submitted the application for the name of “China Geothermal Town” in 2005. In February 2006, the MLR and the CMA awarded Xianyang City as the first “China Geothermal City”.

During the 3 years from 2006-2008, the Xianyang Municipality performed the following works of “China Geothermal City” construction:

- The Office of Geothermal Resources Development Management in Xianyang City was formed.
- The Xianyang Regulation of Geothermal Resources Management and Geothermal Resources Exploitation and Utilization Scheme in the Xianyang Urban Area were promulgated.
- A detailed geological exploration and scheme for a 300 km² urban area was completed, and normal geological work for 1000 km² was initiated in the northwestern part of the city. 2 wells were successfully drilled in Xingping County and Wugong County, proving that rich geothermal resources rich were located in the northwestern part of the city. 70°C water from another well drilled in northeastern Xianyang proved that geothermal resources occur in this area as well.
- Enhanced geothermal man power education was initiated. 45 trainers for different purposes were trained in the Xianyang Geothermal Training Center, which was co-organized by Shanxi Energy Technology College and Sino-Icelandic Greensource Geothermal Energy co-Ltd.
- National and international cooperation was strengthened. In 2006, the China Petrochemistry Industry Group Xinxing Oil Company and Inceland Enex Company successfully co-formed Shanxi Green Source Geothermal Energy Development co-Ltd. The Hong Kong and China Travel Group co-invested in Xianyang. The U.S and Japan became highly interested in geothermal projects in Xianyang. A project for the study of a low-moderate temperature geothermal power plant was negotiated with the U.S.
- Technological exchange and cooperation was organized for geothermal sustainability development. The “China-Iceland Geothermal Technology Workshop” held in February 2008 resolved difficult problems such as reinjection in Xianyang, and the “High Level Workshop for Scientific Development of Geothermal Resources in China” held in November 2008 released novel international and domestic achievements in geothermal exploration, electricity production, house heating, ground source heat pumps, geothermal engineering systems, and discharge reinjection.
- New and large projects were built rapidly. The “Comprehensive exploitation and utilization geothermal resources” project, in which Shanxi Green Source Geothermal Energy Development Co.Ltd invested 40 million US Dollars in the drilling of 8 production wells and 1 reinjection well, realized a house heating area 1.2 million m². The “Xianyang Haiquanwan Hot Spring World” project, which received an investment of 40 million US Dollars from

Hongkong and China Travel Group and has a building area of 53000 m², has been operating since 2008. It is the largest indoor comprehensive holiday venue in northwestern China at present. The “Yuquan West Road geothermal multiuse” project, which received investment from Xianyang Huabei Geothermal Exploitation Co Ltd., has finished the drilling of 1 production well and realized a 100,000m² heating area. The project plan includes the drilling of 3 production wells and 1 reinjection well and a total heating area of 500,000m².

- A long-distance auto-monitoring system was built with Tianjin City in order to carry out high-tech auto-monitoring of geothermal water level, temperature, quantity and pressure in the entire city area. The next step is the construction of a geothermal reservoir model. The auto-monitoring control center was finished in 2008, and some geothermal wells have been entered into the monitoring system.
- Some projects have been prepared to attract investment from the public market: Zhongdi Hot Spring Sanatorium, Zhouling Geothermal Spring Multiple Utilization, Shanxi Buchang International Geothermal Town of Health & Tourism, Xianyang Take-Disease-Out Hot Spring Sanatorium Center, Blue Lagoon Hot Spring Holiday Hotel, etc.

A comparison of geothermal utilization criteria in Xianyang before and after it was named a China Geothermal City is provided in Table 2. This clearly indicates that achievements of geothermal contributions in only 3 years far exceeds those in the former 13 years. The important aspect of this is that geothermal development has been very healthy in Xianyang since it received the title.

Table 2: Comparison of Xianyang before and after it was named a China Geothermal City

Subject	Before named (2005)	After named (2008)
Management organization	no	yes
Government Regulation	no	yes
Geothermal scheme	no	yes
Well number	23	40
Reservoir evaluation	no	yes
Heating area	1,000,000m ²	2,100,000m ²
Annual production	2,000,000m ³	4,000,000m ³
Man power training	no	yes
Technology exchange	no	yes
Auto-monitoring	no	yes
Re-injection	no	yes
Important projects	no	3
Heat pump	no	yes
Pipeline web	no	yes

4. XIONGXIAN MODEL

Xiongxian County is located in the middle of Jizhong Plain in North China. It belongs to Baoding City in the Hebei Province. Its total land area is 524 km², and the population is 338,000. It is a very small county in Baoding City, and its economic status is normal without important industry. However, oil production was realized in the main area of the large Niu Tuo Town Geothermal Field in the 1970's, including Xiong County, Bazhou County and Gu-an County. The geothermal reservoir in Xiongxian is 320 km² and the fluid reserves are 82.17 billion m³. The annual mineable fluid is 8.165 million m³. Well depths range from 520 – 1300 m, and temperatures range from 58 – 86°C. The main geothermal use is house heating, but the resource is also used for greenhouses, fish farming, bathing, etc.

Seeking to become a “bright dot” in the county, the Xiongxian County Government chose geothermal development as its target for economic and social development. The Government submitted the application to the MLR and the CMA in 2005, and in March 2006, the MLR and the CMA awarded Xiongxian as a “China Geothermal Town.” After nearly 4 years of construction and operation, great, visible changes in geothermal development have validated the government’s decision.

The following works have been performed in the “Xiongxian China Geothermal Town”:

- The nationally owned “Green Spring Geothermal Resources Development Co Ltd.” Was formed on behalf of the local government’s geothermal operating behavior. For example, well drilling was controlled by the company to monopolize the first exploitation market and resolve the heating project construction charge in order to create a structured exploitation market.
- The Xiongxian Regulation of Geothermal Resources Management and the Geothermal Resources Exploitation and Utilization Scheme were promulgated in the Xiongxian area. An encouraged exploitation area, a limited exploitation area, and a compulsively restricted exploitation area were demarcated in the scheme.
- A geological evaluation of the geothermal resources in the entire area was completed. The geothermal reserves and annual mineable resources were ascertained by the National Mineral Reserve Committee.
- New technology was used in well drilling and heating. 5 newly drilled wells exhibited improved production from 70-80m³/h to 150m³/h, and the heating area was boosted from 50,000-60,000m²/well to 110,000-120,000m²/well. Radiator heating style was replaced by “step by step floor heating.”
- A long distance auto-monitoring system was built to monitor water level, temperature, quantity and pressure. All geothermal wells were entered into the monitoring system. The updated mining quantity in 2008 was 1 million m³. Labor was reduced, but accuracy was improved.
- Reinjection was forced from 2008, mandating that new production well drilling must include reinjection wells. A reinjection study was carried out with Beijing.
- The “No Smoking Town” Project was put forward by the local government. According to this project, by 2020, the total concentrated heating area in the urban area will be 3.5 million m², with more than 2 million m² of district heating and 1.3 million m² of heat pump use. 0.93 million m² of district heating and 0.1 million m² heat pump use were the current values when this paper was finished, and a new 0.20 million m² of geothermal heating will be introduced in the winter of 2009.
- Large projects have operated smoothly. Since 2007, China Developing Bank has invested ¥ 31 million in the “No Smoking Town” project, which includes the drilling of 5 geothermal wells and a heating ability added 650,000 m². An Asian Bank investment loan of US \$ 12.5 million in the same project has passed feasibility study investigation and entered into phase of inviting tenders. In this branch of the project, there are 11 production wells, 10 reinjection wells, and 55,000 m of transportation pipeline, resulting in a total potential heating ability of 1.65 million m². Other projects are being negotiated with domestic or overseas parties such as Tianjin, Shandong Province, China Petro-chemistry and Iceland.
- Heat pump technology and solar power use were integrated into the “No Smoking Town” project. Geothermal utilization in eco-agriculture and eco-livestock husbandry industry is rising.
- Government work is being performed to recover old wells, confirm owner rights, utilize resources, conduct technical training, etc.

A comparison of the geothermal utilization criteria in Xiongxian before and after it was named a China Geothermal Town is provided in Table 3. It is obvious from this comparison that in a small zone, a regionally characteristic famous brand is very important and effective for the local government to disseminate and develop its economy and society.

Table 3: Comparison of Xiongxian before and after it was named a China Geothermal Town

Subject	Before named (2005)	After named (2008)
Reservoir evaluation	no	yes
Goverment Regulation	no	yes
Geothermal scheme	no	yes
Well number	22(18 used)	27
Heating area	400,000m ²	930,000m ²
Heating area /well	50,000-60,000m ²	110,000-120,000m ²
Production/well	70-80m ³ /h	150m ³ /h
Heating style	radiator heating	floor heating
Auto-monitoring	no	yes
Re-injection	no	restrict
Important project	no	3
Heat pump	no	yes
Pipeline web	no	yes

5. CONCLUSIONS

(1) In the new wave of renewable resources exploitation and development, geothermal resources utilization is rising rapidly. It is urgent that problems caused by disorganized exploitation be eliminated by rational management regulation for ordering development behavior.

(2) The “China Geothermal Town” naming action organized by the MLR and the CMA is an experimental method that combines administrative means and socialized management according to local economic development requirements and a hankering for a famous social brand. Practice proved the great benefits of the “China Geothermal Town” program.

(3) “China Geothermal Town” construction greatly improved economic and social development for moderate and small regions and outlying districts. In these areas, geothermal resources were rich, but local economies were far behind more developed areas, and some were even regressing. A coincident way with local characteristic and also different with others as “bright dot” to promote development is very important to local development planning. The reputations of Xianyang City, a moderate city in northwestern China, and Xiongxiang County, a small county in northern China, are not very large in China. Both need a “bright dot” as their development target. The “China Geothermal Town” program promoted great development in these two regions at a rate never before realized.

(4) New domestic and international technology and advanced methods of resources evaluation, large-diameter well drilling, old oil well renovation, auto-monitoring, reinjection, cascaded use of discharge, etc. were widely spread during the process of “China Geothermal Town” construction. Xianyang cooperated with Iceland, whose geothermal utilization level and technology can be considered first in the world, and Xiongxiang County adopted new methods from Beijing and Tianjin, its neighboring developed cities. Some compelling measures were adopted and accepted by users and the public, including auto-monitoring systems and reinjection policy.

This is incredible progress, because it was previously very hard to enforce due to high costs of installation and operation.

(5) Local governments must attach high importance to the application for the “China Geothermal Town” naming action. “China Geothermal Town” construction is a complex, long-term, and systematic process. It deals with different management departments for regulation, planning, land and resources, city public facility construction, and environment protection. Only the central government can command and control these departments to fulfill their respective work. Realizing this aspect, the MLR and the CMA required the local government must be the applicant for the name of “China Geothermal Town”. The Xianyang Municipality and Xiongxiang County People’s Government were applicants to this program.

(6) After 5 years of operation, the MLR and the CMA should carry out a summary study to complement and perfect original standards and regulations, direct service work for local interests, and duly correct unfavorable trends like the “attention to name but not construction” in order to improve the program.

(7) Examination and inspection work should be performed on a regular basis. Various workshops, forums, summary meetings, and working conferences should occur often for the widespread dissemination and popularization of geothermal development.

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