Proceedings of the 6th Asian Geothermal Symposium, Oct. 26-29, 2004
Mutual Challenges in High- and Low- Temperature Geothermal Resource Fields, 85-90

NEWEST STATISTICS OF GEOTHERMAL DEVELOPMENT IN CHINA

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ABSTRACT

In order to prepare the country update report for the WGC2005, Geothermal Council of China Energy Society collected and processed the newest statistic data which concerned to geothermal development utilization and various corresponding inputs from all over the country. The total utilized energy of direct-use of low temperature geothermal resources in China has now reached 10,779 GWh/yr, or said 38,804 TJ/yr. It has increased 23.6% than in 5 years ago. This statistics reflect a steady progress of geothermal development in China, but also reflect a certain of problem. More new wells drilled in a given geothermal field that led to a decrease of capacity factor. The percentage of geothermal power in new energy power has also decreased in recent years.

Keywords: statistics, geothermal development, China

1. INTRODUCTION

In order to prepare the country update report for the WGC2005, Geothermal Council of China Energy Society collected and processed the newest statistic data which concerned to geothermal development utilization and various corresponding inputs from all over the country. The total utilized energy of direct-use of low temperature geothermal resources in China has now reached 10,779 GWh/yr, or said 38,804 TJ/yr. It has increased 23.6% than the statistics of WGC2000 at 5 years ago. However, geothermal development has had a steady progress in China. But the statistics also reflect a certain of problem, which we shall analyze in this paper.

2. PRODUCTION OF ELECTRICITY IN CHINA

Fuel electricity (coal fired mainly) occupies dominant position absolutely in production of electricity in China. Its capacity is now 332,550 MWe and reaches 76.8 % of total electrical capacity in the country. Its gross production is 1,806,740 GWh/yr and reaches 83.9 % of total production of electricity in the country. Secondary, hydropower occupies the second position. The total capacity of hydropower is 93,070 MWe, it shares 21.5 % of total electrical capacity in the country. Its gross production is 297,800 GWh/yr and reaches 13.8 % of total production of electricity. The third one is nuclear power. It owns a capacity of 7,000 MWe and shares 1.6 % of total electrical capacity in the country. Its gross production is 48,300 GWh/yr and shares 2.2 % of total production of electricity.

Geothermal power generation as new energy utilization was started in 1970s in China. At the early stage the testing power generation of low temperature geothermal water was carried out in 7 locations in the country. The first high temperature geothermal power station was established in Yangbajain of Tibet and stated operation in October of 1977. It was extended into both of south plant and north plant with total 9 units installations. The Yangbajain Geothermal Power Plant has a total capacity of 25.18 MWe (operating 24.18 MWe now). Geothermal power generation was the pride of the new energy utilization until 1990s. But later on, there was not any increase of new installation in recent 13 years. However, wind power has had a rapid growth widely in remote rural areas in northern China. Although its single unit is very small, likes for single family use, but the total capacity of wind power has reached 352 MWe in the country. It has absolutely much exceeded geothermal power. The capacity of wind power shares 0.08 % of total electrical capacity in the country. Its gross production shares 0.05 % of total production of electricity. Meanwhile, capacity of geothermal power shares 0.006 % of total electrical capacity and its gross production shares 0.004 % of total production of electricity.

Table 1. The Growth of Geothermal Direct Use in China

Year	Flow Rate		Capacity	Annual Utilization	
	kg/s	10^6 m^3/yr	MWt	GWh/yr	TJ/yr
1999	12,677	400	2,814	8,724	31,403
2004	13,756	434	3,056	10,779	38,804
Growth in 5 years	8.5 %		8.6 %	23.6 %	

3. DEVELOPMENT OF GEOTHEMAL DIRECT USE

According to the newest statistics, the geothermal direct use in China extracts low to medium temperature geothermal water about 434 million m^3 per year, or say 13,756 kg/s. It is equivalent to a capacity of 3,056 MWt. The utilized geothermal energy reaches 10,779 GWh per year, or says 38,804 TJ per year. These numbers have had an obvious increase than the data in 5 years ago (Table 1).

3.1 Geothermal District Heating

Geothermal district heating has a rapid growth in Tianjin, a big city in North China. Unfortunately, the early infrastructure missed public space heating system in the city. So geothermal district heating just adapted to the demand, because there was no space for installing a boiler-house and the environment protection has not permitted to use coal-boiler in the urban of the city in 1990s. Since that time, geothermal district heating has been growing rapidly. Thermal water of 80-96°C was found in deeper reservoirs of lower Palaeozoic and Proterozoic basement rocks in the city. It is very suitable for the utilization of geothermal district heating. So geothermal district heated area increases near 1 million m^2 per year. The total area of geothermal district heating has reached 9.2 million m^2 at present. It occupies 72 % of the total area of geothermal district heating in the country. Its capacity is 395.6 MWt and the annual utilized energy is 1,281 GWh.

Geothermal district heating is also carried out in Lindian County in paramos of Helongjiang province, the northeast China. A lot of oil-gas exploration wells were drilled in the county, the neighbor of the Daqing Oil Field in order to keep the sustainable production. Some of wells produce hot water with artesian flow in certain temperature there. Local people re-constituted 2 old exploration wells and drilled 8 new wells since 1998. Total 310,000 m^2 of geothermal district heating were operated with a warm water supply for 3,000 houses, saved coal of 8,700 tons per year. It reduced air pollution in the county correspondingly.

Geothermal space heating has also a certain growth in Beijing, Xi'an and some small cities in North China Oil Field. The total area of geothermal district heating has now reached 12.72 million m^2 in China. The capacity of geothermal district heating is 550.3 MWt and shares 18.0 % of total capacity of geothermal direct use. Its utilized energy is 1,775.4 GWh annually and shares 16.5 % of total utilization of geothermal direct use.

3.2 Geothermal Greenhouse Planting

It is a better way to use low temperature geothermal water for greenhouse use. There is a cold winter in North China. It was not possible to produce fresh vegetables there. People ate stored Chinese cabbage and radish as winter vegetables in Beijing and other cities of North China before. Along with the rising of living standard people like to eat various fresh vegetables in winter. Coal fired greenhouse was adopted to fit in with the market demand at the beginning. It needs high cost and is difficult to control the temperature. Geothermal greenhouse can solve these problems. It is easy to adjust and keep the steady temperature, and has a cheap cost. So that, geothermal greenhouse obtains development and popularization progressively. There is large progress in greenhouse technology during recent years. The past greenhouse was usually in an area of 330 m^2. There are many large greenhouses now in Beijing and Tianjin with an area larger than 10,000 m^2. The biggest one has reached in 30,000 m^2. They are all controlled through computer to obtain adjustment of temperature and moisture. The total area of geothermal greenhouse in China is about 1.33 million m^2, with more than half in Hebei province and Beijing.

Geothermal greenhouse produces anti-season top-grade, fine and special vegetables, and also produces flowers. The fresh flowers are especially supplied to the large demand of Chinese Spring Festival - the most traditional festival in China. The Chinese Spring Festival is the new year's day of the lunar calendar. It is usually in ends of January to beginning of February. There is the coldest weather during the period. At the past fresh flowers were transported by air from Guangdong province to Beijing and other big cities in North China. It is now improper to fit in with the large market demand. Therefore, geothermal greenhouse planting flowers has become a hot business for earning money in Beijing, Tianjin and surrounding areas.

In addition, hydroponics and tissue culture have gotten full play in geothermal greenhouse due to the steady temperature, moisture, and germ-free conditions. Some demonstrations of modern agronomy gardens have established in Beijing and Tianjin based on geothermal agricultural utilization.

The total capacity of geothermal greenhouse in China is now 102.6 MWt, and the utilized energy is 326.6 GWh/yr. They share the percentages of 3.4 % and 3.0 % of overall geothermal direct use in China respectively.

3.3 Geothermal Aquaculture Feeding and Breeding

Hubei province is located at north of Yangtze River in Central China. There are more than 600 lakes in the province. Its winter temperature of 1-5 °C made the impossibility for fish feeding and breeding at the weather. Along with the rising of living standard a demand of fresh fish is increasing there. Therefore, the superiority of geothermal resources was used for developing the geothermal aquaculture feeding and breeding accordingly. Geothermal aquaculture has reached an area of 1.4 million m^2 there. It is the largest area of geothermal aquaculture in China. They produce various fresh fishes to supply to Wuhan, the province's capital city and other cities.

There is a total area of 4.45 million m^2 for geothermal aquaculture feeding in China. Geothermal eels were fed in Guangdong and Fujian provinces for export to Japan. Although a decrease due to limited export, there is still an area of 1.34 million m^2 in operation. In addition, geothermal aquaculture is also operated in Hunan, Hebei provinces and Beijing with corresponding area of 0.48, 0.31 and 0.25 million m^2 respectively.

The total capacity of geothermal aquaculture in China is now 174.4 MWt and the utilized energy is 533.6 GWh/yr. They share the percentages of 5.7 % and 5.0 % of overall geothermal direct use in China respectively.

3.4 From Hot Spring Bath to Medical Care to Hot Spring Entertainment

Hot spring bathing is a traditional favor in China with the civilization of the eastern classical country. Hot springs nearby cities and towns were almost used for bathing in the country. The hot spring 'Hua-qing Pool' in Xi'an has had a history of 2,800 years by tradition. An ancient emperor Xuanzong brought his highest-ranking imperial concubine Yang together to take bath in the pool in Tang Dynasty about 1,270 years ago. The famous poet Bai Juyi described the story at that time: 'Bathing in Hua-qing Pool in a cold spring season, washing rouge away in smooth hot spring water'. One other hot spring named 'the First Pool in the World' in Annin County, Yunan province has had a history of some 2,000 years. There are a lot of bathing facilities based on either ancient hot springs or present geothermal wells throughout the country.

Hot spring water contained a certain of mineral compositions with warm temperature can effectively treat some diseases. So it is good for health care in friendly condition. In past period of the planed economy, medical treatment by hot spring was limited in hot spring sanatoria. There are about 400 hot spring sanatoria in the country. Since 1990s along with the great demand of the market economy and the popularization of geothermal wells, geothermal (hot spring) health care and medical treatment have had strong growth especially in Beijing, Tianjin and Xi'an etc. big cities and coastal regions e.g. Guangdong and Hainan provinces. Furthermore, under the driving of a market economy, borrowing the conception of hot spring health care, various hot spring entertainments obtain great development in all over the country. Newest 'Hot Spring World' or 'Hot Spring Paradise' opens their business continuously year by year in a same city. They include hot spring swimming, amusement and bathing, accompanying with sauna, physiotherapy, bowling, tennis and karaoke, combined with hotels, villas and even conference center and real estate to have formed a new hot spring service business. Its attracted high consumption and brought high returns won many investors great admiration.

These hot spring bathing plus hot spring health care and hot spring entertainment consume geothermal water 0.82 million m^3 per day in average. It is equivalent to a capacity of 1,991.4 MWt, sharing 65.2 % of total capacity of geothermal direct use in China. Its utilized energy is 6,970.8 GWh annually, sharing 64.7 % of total utilization of geothermal direct use in the country.

3.5 Other Aspects of Geothermal Direct Use

Low temperature geothermal water is usually 'soft water'. It is suitable for washing and dying in textile and leather -working industries. It is also used for air-conditioning of temperature and moisture in workshops. Some thermal water can be applied as drinking mineral water or additive of food production, and for ice making and cooling etc. Geothermal water is used for crops drying and farmland irrigation in agriculture.

A few geothermal deep wells are used for monitoring of water level, temperature and contents of radon. Their anomaly is used as a factor for analysis of earthquake prediction.

These other aspects utilized geothermal energy of 1,172.3 GWh annually. It shares about 9.9 % of total utilization of geothermal direct use in the country.

3.6 Rapid Growth of Ground Source Heat Pump

There was a rapid growth of ground source heat pump (GSHP) in the world in recent ten some years. GSHP has been

involved into geothermal domain internationally. The development and popularization of GSHP technology have also appeared a trend of rapid growth in China in recent years. GSHP can be used for space heating at winter and for air-cooling at summer. It consumes 1 kWh of electricity but generates 3-4 times of heat energy. So it gets favor from public. It is wonderful that GSHP space heating had reached an area of 2.74 million m^2 in Beijing. That is to say, during a short period of several years it has reached near 6 times of the area of geothermal space heating. Looking at all over the country, GSHP space heating has reached a total area of 6.3 million m^2. Its capacity is about 631 MWt with the annual utilized energy of 1,825 GWh.

4. GEOTHERMAL EXPLORATION AND WELL DRILLING

During the past period of planned economy, geothermal exploration was national input. When a geothermal field had explored then geothermal users bore the drilling cost for their production well. There was no risk for geothermal user at that time. When 1980s along with the restructuring the economy from socialist planned economy to market economy in China, the national investment has much decreased. Considering a high risk for geothermal exploration, private investors looked about and made no move for a short period. Later on, investors found its high repayment, so they put investment actively in geothermal drilling in order to open their geothermal business. Many new wells were drilled year by year in Beijing, Tianjin and Xi'an etc. big cities. And also in many other areas the local first geothermal well was successfully drilled almost one by one, such as in Yinchuan, Nanning, Jinan and Dalian etc. cities. As an example showed in Figure.1, we can see the increasing trend of geothermal well drilling in Beijing. In the latter stage of 1950s the first exploration drilling was started in Xiaotangshan hot spring area, north suburb of Beijing in order to keep the hot spring utilization in local sanatorium. In 1960s oil exploration carried out in south suburb and found low temperature thermal water there. Formal geothermal exploration was started in the beginning of 1970s in downtown of Beijing. A series of geothermal wells were drilled following the reconnaissance, detailed survey and exploration stages. And it was extended to surrounding suburbs progressively. However, a rapid increase was started in latter 1990s and lasted until now. The completed geothermal well drilling in the 21st century was 50-70 km every year.

Look at a number, the geothermal well drilling completed 574 km in all China in recent 5 years. The most of them are production wells, with a few of combined production-exploration wells. The real exploration well with national investment is only 5.3 % of them. Reinjection well drilling is only in rare percentage, say 5.7 % of total geothermal drilling.

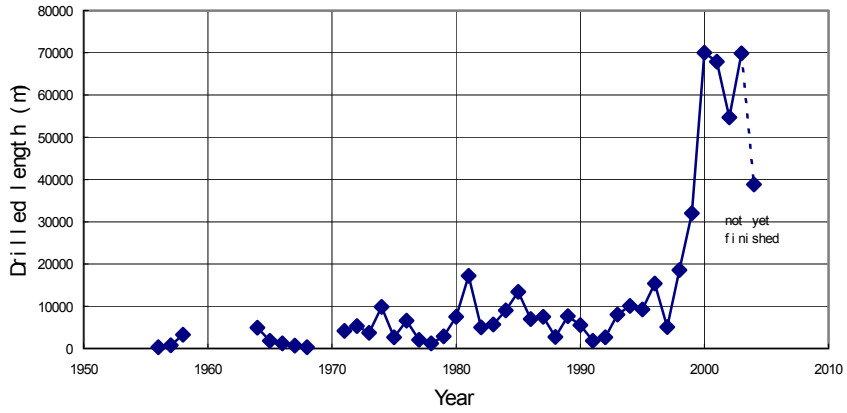

Figure 1. Geothermal well drilling completed in China

5. PROFESSIONAL PERSONNEL AND GEOTHERMAL INVESTMENTS

Geothermal Council of China Energy Society (GCES) has been having some 800 members since its foundation 20 years ago. But the structure of GCES members has changed obviously. During the period of planned economy in 1970s to 1980s the Ministry of Geology and Mineral Resources had its geological bureaus and geological teams in each large cities, provinces and autonomous regions to carry out geothermal survey and exploration. Their professional personnel formed the main part of the membership. Then included researchers from concerned universities and institutes. The membership involves both specialities of geothermal exploration and geothermal utilization (power generation and non-electricity use).

Since 1990s fitting in with the demand of market economy the geothermal technology has covered wider specialities, e.g. GSHP, geothermal physiotherapy, geothermal agronomy, geothermal construction, hot spring entertainment, monitoring and automatic control etc. Many private companies opened their services in someone of above specialities. Many old experts retired. Many new experts from concerned private companies took part in. There are 746 professional personnel now undertaking geothermal exploration, development, utilization and management. Their structure is shown in Table 2.

Table 2. The Structure of Geothermal Professional Personnel in China

	Government plan & managing	Public Utilities	University & Institute	Private Company	Others	Total
Personnel	148	332	78	185	3	746
Percentage	19.8 %	44.5 %	10.5 %	24.8 %	0.4 %	100 %

During past 5 years from 2000 to 2004 the total investment in geothermal development in China covers following aspects:

a. Research, survey and exploration drilling: 5.4 million US Dollars. This belongs to national input;
b. Field development including production drilling and surface equipment: 80.9 million US Dollars;
c. Geothermal utilization construction and facilities: 172.8 million US Dollars.

The latter two items belong to private funding. They occupy a percentage of 97.9 % in total investment. So the national investment is only 2.1 % now.

6. WHAT CAN YOU SEE FROM THE STATISTICS

Taking a panoramic view of the statistics, there is half happiness and a half worry. The statistics reflect a progress in recent years. But also reflect a certain of existing problem.

a. Table 1 shows a growth of geothermal development in China during recent 5 years. The total flow rate extracted geothermal water has an increase of 8.5 % than in 5 years ago. The total capacity of geothermal direct use has also increased 8.6 %. These two numbers look like not so big. But the annual utilized energy increased 23.6 %. This means that the efficiency of geothermal utilization has had a significant increase. In fact, based on a given flow rate and capacity, the utilized geothermal energy has obviously increased. Comparing to the statistics in WGC2000, the general capacity factor was 0.35. But it is 0.40 now for the year of 2004.
b. Corresponding to an increase of geothermal production wells, the capacity factor for single well showed a decrease clearly. Geothermal direct use in China belongs to scattered isolated development in a same geothermal field by each individual investor. So this could not form a centralized large-scale development. Private investors have paid attention to saving electricity, water and energy, but they do not want to give the saved resources to their competitions. New investors have to drill their own new well. This resulted that the more wells drilled, the less capacity factor appeared. A typical example is in Beijing. There was few geothermal well in 1950s to 1960s, its capacity factor was 0.50 at that time. Along with an extension of geothermal wells in 1970s to 1980s, its capacity factor decreased into 0.32-0.33. Furthermore, the capacity factor decreased into 0.26 in 1990s. And it has dropped into 0.15 now in the 21st century.
c. Unfortunately, there was not any increase of geothermal power generation in the past 13 years in China. Therefore, in new energy family the wind power has had significant progress. Wind power has exceeded 10 more times of geothermal power now.
d. Geothermal resources management has been implemented in Beijing, Tianjin etc. cities. A given flow rate of permissible extraction was assigned by the geothermal management administration. The administration collects also a compensation of geothermal resources from users. These countermeasures have effectively controlled a waste of resources. Water head pressure of geothermal reservoirs has an annual drowdown of 1-2 meters in Beijing usually. Unfortunately, reinjection well drilling and reinjection rate are still small. Some errors appeared in early development, such as low efficiency use and resources waste, is now repeated in some new developing areas. We have to correct them.

ACKNOWLEDGMENTS

Author would like to express his thanks to concerned members of Geothermal Council of China Energy Society distributed in all over the country for providing recent data cited here. It gave the possibility to take into account for the statistical data national-wide.

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