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GEOTHERMAL RESOURCES AND USE FOR HEATING IN CHINA

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ABSTRACT

There are rich medium-low temperature geothermal resources and few high temperature geothermal resources in China. Geothermal exploration and detailed surveys were carried out for small parts of them. Geothermal reconnaissance has been carried out for most of them. The Yangbajain geothermal power plant is a typical development for high temperature resources in China. Medium-low temperature geothermal resources are used directly for geothermal space heating, heating in greenhouses, aquaculture, bathing and medical care, relaxation and entertainment etc Forecasts to 2020 predict that geothermal direct heating use in China will be equivalent to that of a 1,300 MW dummy power plant running at full capacity for one year. Meanwhile, GSHP heating would save the amount of electricity equivalent to a dummy power plant of 1,900 MW running at full capacity for one year.

1. GEOTHERMAL RESOURCES IN CHINA

There are more than 3,000 locations of natural hot springs distributed throughout various locations in China. Dense hot springs with highest temperatures are concentrated along two zones. One is from Tibet to the western Yunnan province; the other is along the south-eastern coastal area, including the Fujian, Guangdong, Taiwan and Hainan Provinces. In addition, there are about 3,000 geothermal wells drilled in China distributed in both plain and basin areas.

1.1 Types of geothermal systems

Natural hot springs, geothermal surface manifestations, and geothermal wells represent two types of

geothermal systems.

1.1.1 Geothermal high temperature convection system

As an example of geothermal high temperature convection system the Dagejia Geyser regularly gushes out steam and hot water to a height of 20 m. In the Yangbajain geothermal field deep exploration has uncovered temperatures up to 329.8°C. all high temperature convection systems are located in Tibet in the east section of the global Mediterranean – Himalayan geothermal zone. Due to the most recent Neo-tectonic movement, intensive, hydrothermal convection happens from high temperature areas in the vicinity of a magma chamber under thin crust via faults to the surface. By reconnaissance, 131 high temperature geothermal fields were found along this zone. Eight of them have a temperature higher than 200°C. The Yangbajain geothermal field is a typical example of this type of system. The well ZK4001 completed in 1997 yielded 302 tons per hour of steam and hot water . Its wellhead temperature was 200°C. The working pressure was 14.7 MPa. Its single well potential for power generation is 12.58 MW.

1.1.2 Medium-low temperature conduction geothermal system

About 3,000 geothermal wells have been drilled in China. Most were drilled in large to medium sedimentary basins. These geothermal resources belong to conductional geothermal systems. Bedded permeable strata can form porous or karst reservoirs. When situated under an impermeable “cap rock” so that heat is preserved within the rock, the reservoir gains heat through conduction from deeper strata. The highest temperature found in drillholes is 120°C. But most are less than 90°C, which is classified as low temperature resources (geothermal water).

1.2 Estimation of geothermal resources

A total of 103 geothermal fields have been explored in China and the exploitable geothermal water resources amount to a total of 333 million m^3 annually. Detailed surveys for another 214 geothermal fields have been conducted and the associated exploitable geothermal water resources are 500 million m^3 annually. Most of these geothermal fields are located in sedimentary basins. The sum of the geothermal resources reserved in the main sedimentary basins has been estimated as 73.61×10^{20}J, equivalent to a total heat of 250 billion tons standard coal. The potential of exploitable geothermal water resources is 6.845 billion m^3 annually, equivalent to 32.847 million tons standard coal annually.

2. GEOTHERMAL UTILIZATION IN CHINA

High temperature geothermal resources are suitable for power generation. While medium-low temperature geothermal resources are suitable for various direct use.

2.1 High temperature geothermal power generation

High temperature geothermal power generation mainly takes place in Tibet. The Yangbajain geothermal field was explored and high temperature steam and hot water of 160-180°C was found. Its potential is 30 MW. The Yangbajain geothermal power plant started as a 1 MW pilot plant in 1977. Its installed capacity reached 25.18 MW in 1991. It is divided into a south plant and a north plant. The south plant comprises the installed 1 MW test unit and 3 × 3 MW units. The north plant comprises 4 × 3 units and a 3.18 MW unit, a total of 5 units. The power plant is called "the bright pearl on the world's roof", and it played a key role until the middle of the 1990s in solving the electricity shortage in Lhasa city. It satisfied 50 % electricity demand in Lhasa, and specially 60 % in winter. After the completion of the Yamzho Yumco Hydropower Plant, the geothermal installed capacity was reduced to 12% in total installed capacity but out of the total power demand in Lhasa, geothermal electricity accounts for 25% in summer and 40% in winter. At present, another 25 MW is planned for the Yangyi geothermal power plant. In addition, other 2 × 1 MW units were installed in Langju of the Arli area but only 1 MW can run for 400 kW load. Furthermore, 1 MW is installed in the Nagqu County but it was taken out of production due to a serious scaling problem.

2.2 Medium-low temperature geothermal direct use

Hot spring water and medium-low temperature geothermal resources has comprehensively been used as new energy in China since 1970s. It is utilized for space heating in the winter in addition to agricultural greenhouse heating, aquaculture, bathing and medical care etc.. There has been a great increasing in recent years to meet the demand of of the modern market economy. Geothermal water can be effectively used for space heating in winter season especially in northern China instead of conventional fuel boiler. It diminishes air pollution, so it is in people's good graces. The total area of geothermal space heating reached 17 M m^2 in the country in 2007. Geothermal greenhouses have substituted the rough cultivation methods of the past in the countryside of northern China. It produces a variety of high-ranking vegetables during all season. It has also greatly increased the value of farm products. There are a total of 0.8 M m^2 of greenhouse in the country now, mainly in northern China. Geothermal aquaculture has experienced a widespread increase in southern China, in part, due to the high value that they feed some valuable species for export. There are over 200 aquacultural farms with a total area more than 3 M m^2 feeding in the country now, mainly in southern China in the Guangdong and Fujian provinces.

Hot spring bathing is a tradition favoured in by China's ancient civilization. There are about 1,600 places of public hot spring bathing houses and swimming pools in the country. And these account for the largest share of geothermal direct use in China. In recent years, hot spring paradises or hot spring worlds have evolved rather quickly, especially in large cities like Beijing, Tianjin and Xi'an, and coastal areas, such as the Guangdong and Fujian provinces. Medical curing using hot spring is the similarly favour in China. There are 420 places using geothermal water for medical treatment. They either utilize existing hot springs or geothermal wells. One example is the Jiu Hua Spa Resort, located in the Xiaotangshan geothermal field in the northern suburb of Beijing. It is a modern geothermal

recreation and health care centre. They have hot spring baths, hot springs with medicine baths, mineral mud baths, hot spring swimming pools and various hot spring physiotherapy facilities. These are used extensively for recreation and health care, with an annual income over 600 M CNY (1 USD equals about 7 CNY) in 2007. Medium-low temperature geothermal water are also used for other industrial or agricultural purposes, such as drying, cooling, washing and irrigation etc.

According to the statistics of the World Geothermal Congress 2005, China is in first place on the list of top geothermal direct use in the world. It reached 12,603 GWh/a in 2004. In 2007 the number has reached 18,900 GWh.

3. GEOTHERMAL SPACE HEATING USE

3.1 Conventional geothermal space heating

Conventional geothermal space heating usually uses geothermal water with a temperature higher than 50°C. In 2007, the total area with geothermal district heating is 17 M m^2 in China. Based on widespread distribution, higher temperature (bedrock reservoirs are mostly higher than 80°C), and larger yield, Tianjin has reached an area of 12 M m^2. In order to meet an increased market demand, geothermal cascade utilization is carried out in Tianjin. Geothermal water with a temperature higher than 80°C is first used in radiator system,s and then the returned water is used for floor heating. Finally, heat pumps are used to extract more heat from the secondary return water, for additional space heating. Such implementation have increased the heating area from a single well from 100,000 m^2 to 180,000-200,000 m^2.

Excluding Tianjin, geothermal district heating has reached 1.64 M m^2 in Xianyang of the Shaanxi Province, 1 M m^2 in Xi'an city, and about 2 M m^2 in Beijing and the Hebei Province.

3.2 Ground source heat pump utilization

Although research on ground source heat pumps (GSHPs) started early in the 1950s and 1960s in China, its actual practices started by the end of the 1990s. Due to its high efficiency, energy savings, CO_2 emission reduction, and the fact that it is almost suitable everywhere, GSHPs have experienced a rapid growth in recent years. In 2004, GSHPs heated 2.74 M m^2 in Beijing and 7.67 M m^2 in the country. In 2006, there were 369 projects carried out in Beijing with a total area of 7.38 M m^2. Meanwhile, Shenyang city accounts for the largest area. In 2007, Shenyang completed a total of 18 M m^2 of GSHP heating. As a whole, the country covers 36 M m^2 GSHP heating in the year.

4. SUCH DUMMY POWER PLANT

For the function and efficiency of GSHP in China, we can use two dummy power plants as examples.

4.1 A dummy power plant for power consumption

For conventional geothermal space heating Tianjin is a typical representative, and Xianyang follows it closely. By preliminary programming, the growth target for 2020 is that, Tianjin and Xianyang will reach 18 M m^2 and 8 M m^2, respectively. With the addition of other cities with slower growth, the total geothermal district heating will be 30 M m^2. Therefore, we can calculate as following:

Demand of heating installation: 30,000,000 m^2 × 50 W/m^2 = 1,500 MWt,

Actual one year heat used: 1,500 MWt × 120 d × 17 h = 3,030 GWh;

In addition, GSHP programmed 100 M m^2 for Beijing in 2020 and 65 M m^2 for Shenyang, So whole country would be 200 M m^2 of GSHP heating. Therefore,

Demand of heating installation: 200,000,000 m^2 × 55 W/m^2 = 11,000 MWt,

Assuming GSHP has COP=3, so its actual power consumption would be 1/3, 11,000 ÷ 3 = 3,670 MW, while its power saving would be 11,000 – 3.670 = 7,300 MW,

Actual one year heat used: 3,670 MWt × 125 d × 17 h = 7,800 GWh;

Conventional + GSHP = 10,860 GWh,

This equals a full load power plant with the following installed capacity: 10,860 GWh ÷ 330 d ÷ 24 h = 1,371 MW ≅ 1,300 MW. This means, without geothermal district heating, we need a 1,300 MW power plant running at full load to fill the gap.

4.2 A dummy power plant for power saving

Assuming that by 2020 GSHP would reach a heating area of 200,000,000 m^2, the results is a power saving of 7,300 MW (from above calculation).

Actual one year heat used: 7,300 MWt × 125 d × 17 h = 15,512 GWh;

This equals a full load power plant with the following installed capacity: 15,512 GWh ÷ 330 d ÷ 24 h = 1,958 MW ≅ 1,900 MW.

Which means that the power saved by GSHP space heating equals the power generation of a 1,900 MW power plant running at full load.

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