GEOTHERMAL DIRECT USE IN CHINA – COUNTRY UPDATE

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ABSTRACT

Since the first World Geothermal Congress in 1995, China has been keeping the first place for annual energy utilization of geothermal direct use. Along with rapid growth of GSHP, China has gotten up the first chair for installed capacity of geothermal direct use. This is due to that market demand drives growth after China entering the market economy. At recent 20 years GSHP and geothermal district heating developed at top speed relying on the opportunity of energy saving and emission reduction. However, there are some barriers still existed at present. We have to rely on innovation to win through it, in order to more prosperous development.

Keywords: geothermal, low temperature, direct use, GSHP, China

1. BACKGROUND FOR BEGINNING OF 13TH 5-YEAR-PLAN

2016 is the beginning year of 13th 5-year-plan in China. It started in following background concerned to geothermal development.

1.1 Revolution of Energy Production and Consumption

China is implementing the "Revolution of Energy Production and Consumption" in order to ensure national energy security, energy saving and emission reduction, and for haze governing. The country's energy strategy studied by China Academy of Engineering is: diversification and securitization of energy resource guarantee; greenization and high efficient of energy production; informationization and intelligentialization of energy system; and optimal configuration of nationwide energy resources[1].

1.2 Road Map for Geothermal Growth

Chinese Academy of Engineering (CAE) has completed a research project of "Study on Strategy for Promoting the Revolution of Energy Production and Consumption". Each type of energy is drawn a road map of development. Geothermal energy has showed the target for the year of 2020, 2030 and 2050[2]. These targets for conventional hydrothermal resources of direct use and shallow geothermal energy were listed in table 1.

Table 1 Road Map of Geothermal Direct Use in China

Year	2014	2020	2030	2050
Direct use, MWt	6,089	9,752	21,056	67,529

GSHP, MWt	11,781	21,155	42,311	114,240
Total, MWt	17,870	30,907	63,367	181,769

1.3 13th 5-Year-Plan of Geothermal Energy Development and Utilization

The 13th 5-Year-Plan of Geothermal Energy Development and Utilization has had an exposure draft by National Energy Administration (NEA). Geothermal development and utilization will have greater growth than before. GSHP intended to increase 700 million m^2 of application. Geothermal space heating wanted to increase 400 million m^2 of application. Geothermal power generation hopes to increase 2,000 MWe. Geothermal utilization will equivalent to 72.1 million tons of standard coal annually. And it will save 177 million tons of CO_2 emission.

1.4 Completion of Geothermal Resources Survey and Estimation Project

Ministry of Land and Resources (MLR) had ordered China Geological Survey (CGS) to input geothermal survey fund of 600 million CNY (92 million USD) in past 5 years (2011-2015) for the "Geothermal Resources Survey and Estimation" project. It involved shallow geothermal energy, conventional geothermal resources and HDR/EGS resources. The task was assigned to each provinces, autonomous regions and direct-controlled municipalities. Implementation was carried out after unified training for methodology. The task has been completed. It shows geothermal resources potential for 3 types of resources.

2. AVAILABILITY OF GEOTHERMAL RESOURCES

China Geological Survey (CGS) supported "Geothermal resources survey and estimation" project had completed in 2015. It involved shallow geothermal energy, conventional geothermal resources and HDR/EGS resources.

2.1 Conventional Hydrothermal Resources

For low temperature hydrothermal resources which for direct use, both geothermal resources and extractable thermal fluid were estimated respectively. In addition, shallow geothermal energy potential was estimated also for larger cities[3].

(1) Geothermal resources

Volumetric method was used for the estimation of geothermal resources reserved in every sedimentary basin. Estimation calculation was carried out in total 26 of provinces, autonomous regions and direct-controlled municipalities, except 5 mountainous regions of Tibet, Guizhou, Hunan, Fujian and Chongqing from overall 31 in the country. The sum of geothermal resources are 36.6×10^3 EJ. It is equivalent to 1.25 trillion tons of standard coal. The annual extractable energy equals 1,800 million tons of standard coal.

(2) Extractable thermal fluid

Based on explored and surveyed parameters of geothermal fields, analogy method was used to calculate the extractable geothermal fluid. It involves sedimentary basins and mountain areas with hot springs. The total extractable fluid is 23.9 giga m^3/yr. The total extractable thermal energy is 4.77 EJ/yr. It is equivalent to 163 million tons of standard coal annually.

The existing geothermal direct use is equivalent to about 12 million tons of standard coal annually in China. So there is great potential of geothermal resources to support geothermal utilization for sustainable development.

2.2 Shallow Geothermal Energy

Total 31 cities of provincial capital have completed the estimation of shallow geothermal energy in the country. Base on proper use areas and volumetric usage factor to get shallow thermal capacity (TJ/°C) of 0-200 m depth. Base on local site thermal response test in different temperature zones to select reasonable temperature difference for calculating total thermal capacity. Thereafter, based on the heating or cooling period to calculate the thermal exchange power for GSHP system (MWt).

Estimated shallow thermal capacity for Northern China provincial capital cities is 13,763.6 TJ/°C. Its thermal exchange power of GSHP system for summer cooling is 368,605 MWt, and for winter heating is 206,539 MWt. Then, for Southern China provincial capital cities the shallow thermal capacity is 8,316 TJ/°C. Its thermal exchange power of GSHP system for summer cooling is 284,073 MWt, and for winter heating is 257,883 MWt. Therefore for total 31 cities, the shallow thermal capacity is 22,080 TJ/°C. Its thermal exchange power of GSHP system for summer cooling is 652,679 MWt, and for winter heating is 464,422 MWt. The shallow geothermal energy will satisfy for winter heating of 9,288 million m^2 and for summer cooling of 11,867 million m^2.

The same works also be completed in total 318 large and middle cities national-wide. The total potential could satisfy the demand of winter heating for 22 giga m^2, and of summer cooling for 23.2 giga m^2.

For statistics from 661 cities in China, the annual completed total construction area is 1.8-2.0 giga m^2. Assuming the one third new buildings will use GSHP for heating and cooling, the total potential of shallow geothermal energy capacity will be enough for 30 year's use in future.

Taking Shenyang city as an example, which is the first one by rank in China, its shallow geothermal energy could satisfy the demand of 369 million m^2 for winter heating and of 578 million m^2 for summer cooling. These numbers have been larger enough than the total construction areas in the city. About one third of total construction areas have installed GSHP in Shenyang. It still has potential for further use of GSHP. There is enough shallow geothermal energy potential in these cities.

3. GROWTH AND STATUS OF GEOTHERMAL DIRECT USE IN CHINA

Hot spring bath and medical treatment have been for over two thousands year's history in China. That is spontaneous, small scale, simple and crude use. Geothermal resources use with certain scale after exploration and design which differ than previous way since 1956.

3.1 Geothermal Direct Use

Ministry of Geology and Ministry of Health selected 16 hot spring sanatoria to carry out geothermal survey in 1956. The purpose is to ensure the geothermal water supplying for these sanatoria.

J.S. Lee, the Chinese Minister of Geology, initiated geothermal development in China in 1970 when the first crisis of world petroleum price. He pointed out that it is important just likes human founded burnable coal and petroleum. Thereupon, the upsurge of geothermal exploration and development was former in 1970s. There were some geothermal wells exploiting Tertiary porous thermal water with temperature 40~52°C in Tianjin at that time. These thermal waters were used for industrial process such as woolen mill and printing and dyeing mill etc. Ministry of Geology organized a "geothermal battle" in Tianjin. Geothermal water was used for fish farming, hatching, green house and duck processing etc aspects. Geothermal space heating was tested also. It was planning economy at that time. Leader's calling upon plus mass movement formed the first upsurge of geothermal development in China. In 1980s geothermal development was retard due to reduced national input for geothermal exploration.

China implemented the reform and opening-up policy and entered marketing economy in 1990s. Along with economy growth and rising subsistence level, hot spring relaxation and recuperation, travel in holiday, and the hot spring real estate became a very hot market. Private developers purchase land in geothermal areas to put geothermal drilling and development. They gained high profit soon. It made chain reaction afterwards. So it has been bringing continuous growth of geothermal development with annual increase rate about 10%. Additionally, great demand of fresh vegetables, aquatic products and fresh flowers in Beijing, Tianjin and northern big cities made a sustainable growth for geothermal greenhouse.

Geothermal district heating becomes a main flow progressively in geothermal direct use. There was no district heating system in Tianjin before. When they intended to create it in 1980s, there was no space almost between buildings for a boiler house. Later, coal boiler had not been permitted in order to pollution reduction. Just in time, there are rich geothermal resources with temperature over 80°C in urban area of Tianjin. It is very suitable for geothermal district heating in Tianjin. Therefore, Tianjin has been keeping the first place for geothermal heating in the country. The annual energy utilization for geothermal district heating has exceeded the bath and swimming in China.

Since the first World Geothermal Congress in 1995, China has been keeping the first place for annual energy utilization of geothermal direct use in the world. USA is the second one. GSHP occupied 12% of total direct use at that time. Following a great growth of GSHP in Euro-America countries, the first place for installed capacity of geothermal direct use has been keeping by USA until WGC2015. China became the first place both for installed capacity and annual energy utilization in 2015 in the world. It includes great contribution by GSHP.

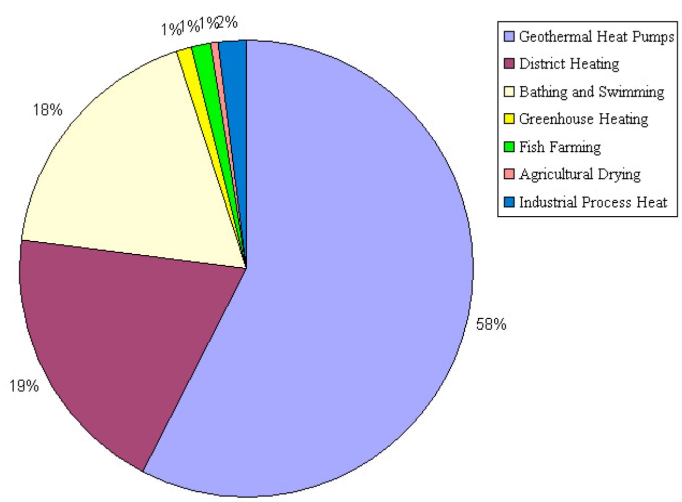

Fig.1 The constitute of geothermal direct use in 2015 in China

3.2 Ground Source Heat Pump

The first GSHP project installed in Beijing in 1995 applied American Carrier heat pump. Consequently other testing projects carried out in Liaoning and Zhejiang provinces.

The recent 20 year's great growth can be divided into two decade. There was very rapid increase rate but limited total quantity at the first decade (Table 2, 3). Installed capacity and annual energy utilization increased 12.1 and 11.9 times respectively during the period of 1995-2000. The average annual progressive increase rate is 65% and 64% respectively. However, the installed capacity and annual energy utilization increased 65.1 and 79.1 times respectively during the period of 2000-2005. Their average annual progressive increase rate is 131% and 140% respectively. The largest increase occurred in 2004. The total installed capacity reached 631MWt in 2005. The annual energy utilization was 6569TJ/yr.

The most recent decade has little reduced speed but very large total quantity (Table 2, 3). Installed capacity and annual energy utilization increased 6.7 and 4.4 times respectively during the period of 2005-2010. The average annual progressive increase rate is 46% and 35% respectively. However, the installed capacity and annual energy utilization increased 2.8 and 3.5 times respectively during the period of 2010-2015. Their average annual progressive increase rate is 22% and 28% respectively. The total installed capacity reached 11,781MWt in 2015. The annual energy utilization was 100,311TJ/yr[4,5].

Table 2 Increase of installed capacity of GSHP in China

Year	1995	2000	2005	2010	2015
Installed capacity of GSHP, MWt	0.8	9.7	631	4,250	11,781
installed capacity of direct use, MWt	1,915	2,814	3,056	3,688	6,089
Total geothermal direct use, MWt	1,915.8	2,823.7	3,687	7,938	17,870
Ratio of GSHP to direct use, %	0.04	0.34	17.1	53.5	65.9
Increase rate than 5 years ago, time		12.1	65.1	6.7	2.8
Ave. annual progressive increase rate, %		65	131	46	22

Table 3 Increase of annual energy utilization of GSHP in China

Year	1995	2000	2005	2010	2015
Installed capacity of GSHP, MWt	7	83	6,569	29,035	100,311
installed capacity of direct use, MWt	16,981	31,403	38,804	46,313	74,041
Total geothermal direct use, MWt	16,988	31,486	45,373	75,348	174,352
Ratio of GSHP to direct use, %	0.04	0.26	14.4	38.5	57.3
Increase rate than 5 years ago, time		11.9	79.1	4.4	3.5
Ave. annual progressive increase rate, %		64	140	35	28

The increase rate of GSHP is far higher than geothermal direct use and power generation in China. It can be seen clearly in Fig. 2.

4. BARRIERS

However, there is still some barriers existed for geothermal direct use in China although it is rather less than geothermal power generation. We have to rely on innovation to win through it, in order to more prosperous development.

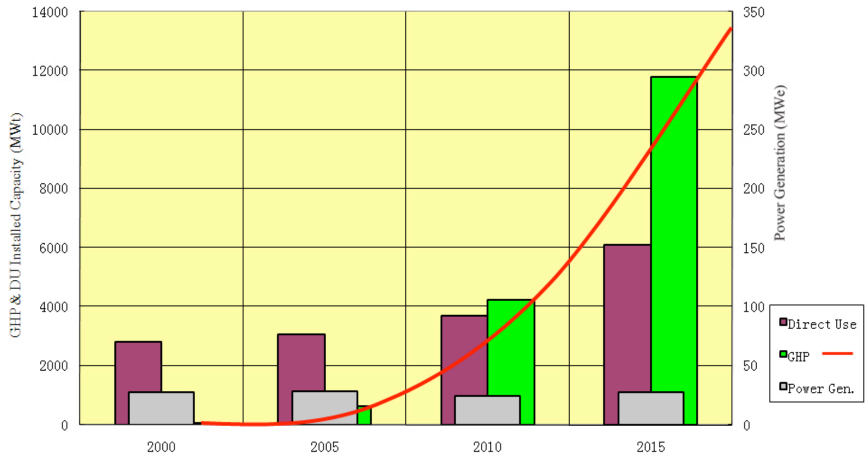

Fig.2 Comparison of GSHP, direct use and power generation in China

4.1 Policy Barrier

Lack of R&D funding: However, the superiority and significance of geothermal resources have not yet been recognized by decision-makers in China. As one of renewable energies, geothermal exploration and development meet larger difficulty than wind energy and solar energy. It needs national support in policy and fund. However geothermal support is far less than wind and solar energies.

4.2 Social Barrier

Lack of expert: It does not fit the greater demand of further growth.

Lack of knowledge: There is no professional geothermal course set up in university. Geothermal workers come from hydrogeologist mainly. They are less knowledge for heat property and transmission technique. Significant research project from national or departmental is less as support for innovative development. Lack of thinking about further improvement for increasing efficiency and decreasing cost.

4.3 Legal Barrier

Legistration/business mechanism: Lack of "Law of Geothermal Resources" or "Management Method of Geothermal Resources". Geothermal resources were administrated as water resources in many cities. Geothermal exploitation needs get licence from the water bureau. The water bureau does not understand geothermal. They did not agree geothermal exploitation because thinking it would drop groundwater level sometimes. Or they approved many geothermal well drilling in a concentrated area sometimes.

4.4 Technical Barrier

Lack of information: Less popularization of integrated and cascade utilization of geothermal direct use. There are some low level and rough use in many places. Resources were wasted and didn't give play to corresponding benefit.

Serious problem is in geothermal reinjection. The reinjection of geothermal tail water didn't be paid attention in many areas. In Hebei plain many developers run geothermal space heating for his real estate buildings independently. They extracted geothermal water for space heating but not for reinjection. Resources were wasted seriously. Reinjection didn't be emphasized by local administrative departments. The technology of reinjection didn't be popularized. Reinjection for sandstone geothermal reservoirs is still technological problem at present. It is important to improve further for increasing efficiency and decreasing cost

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