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Twenty Years of Geothermal Heat Pumps in China

Keyan ZHENG[1], Yiping MO[2] and Ling CHEN[2]

[1]Geothermal Council of China Energy Society (GCES), Beijing 100081, China

[2]Periodical Office of Ground Source Heat Pump, Beijing 100028, China

Kyzheng_gces@163.com

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ABSTRACT

Chinese researchers started study on heat pumps from 1960s. However, geothermal heat pump started practical application in 1990s. It was brought in China again followed its great growth in the world at that time. The first application projects were implemented in Beijing etc. cities.

When entering the 21st century GHP application enlarged further via enhanced exchange between China and foreign countries. Domestic products of heat pumps entered to the market rapidly. The production and selling of heat pumps, and the design and installation of systems grew in step with it. In recent 5 years, GHP showed sufficient superiority in energy saving and emission reduction. So it got support and promotion by governments and leading departments. GHP got cogent growth. The total application areas of GHP were 7.67 million m^2 in 2004. It was 100.70 million m^2 in 2009. Their rated capacities were 383 MWt and 5,210 MWt respectively. In WGC 2010, China had become the second place in the world. In January 2013 the National Energy Administration, Ministry of Finance, Ministry of Land and Resources, and Ministry of Housing and Urban-Rural Development jointly issued a document Guidelines on Promoting Geothermal Energy Development and Utilization. It determined the target for GHP development. To the end of 12th 5-year-plan in 2015, GHP application will reach 500 million m^2. Due to this promoting, GHP application reached over 330 million m^2 in 2014. Its used capacity will be 11.8 GWt and with annual energy used 110,311 TJ/yr. The predicted growth for 2015 would increase 30% further.

During the past 20 years, GHP industry in China has grown out of nothing and expanded rapidly. The industrial high-rise forum was organized every year. The Top Ten Enterprises have been appraised and elected for 5 times annually. GHP industry appears flourishing complexion in China. The state revised code standard also and issued new preferential policy for GHP. More enterprises of heat pump and ancillary materials have been developing and growing continuously. Various companies of design and installation increase again. Universities and research institutes are holding concerned research topics from Ministry of Science and Technology.

1. INTRODUCTION

Geothermal heat pump has sprung up in China. It started in past 20 years. It is not so long time. Even though that Chinese studied heat pump since 1960s, but it was scholar's research in Tianjin University and Tsinghua University. Tests were carried out in laboratory and few engineering sites. There was no condition for practical application due to lack of electricity even for civil lighting at that time.

However, an integrated geothermal heat pump industry has formed suddenly in China within past 20 years. We remember the first geothermal heat pump project application was the New Henderson Building in Beijing, China in 1995. It used the heat pump of Carrier brand which made in USA. Ten groundwater wells were drilled for pumping and reinjection. Since the project implementation Tsinghua University started to develop domestic products of heat pump combining with Shandong Fuerda Co. Ltd. It gained success in 1996 and then extended application spread hereafter. In later period of 1990s a few demonstration projects also appeared in Liaoyang of Liaoning province and Jinan of Shandong province. At that time several universities carried out experimental studies including theoretical mode and testing application (Diao and Fang, 2006). At the end of 2000 GHP reached 100 thousand m^2 of application. GHP got high speed growth when entering the 21st century. The application was 7.67 million m^2 in 2004; and 100.7 million m^2 in 2009. During this period Shenyang exceeded Beijing and became the first place in the country in 2007. It occupied 54% of total application number in China. Hereafter, Shenyang decreased its very-high-speed for partial adjustment but still kept the top position.

However, GHP appears a positive favorable turn in 2010s perhaps due to the stimulation by serious haze in eastern China. So GHP application accelerated again. A new trend shows the most rapid growth appeared in mid-down streams region of Yellow River and Yangtze River where was no winter space heating before. For example in Jiangsu province there was no space heating under planning economy. But its winter air temperature is lower than 5°C, it needs space heating. Developers constructed new buildings including geothermal heat pump in recent years. It is welcome by publics. Another example is in Wuhan city. Local government has comes up with the project called "warm in winter and cool in summer". Therefore, all new buildings will use GHP for heating in winter and cooling in summer. And existing buildings will be remoulded by GHP progressively.

Geothermal heat pump application will reach 330 million m^2 in China in 2014. Its installed capacity will be 11.8 GWt and with annual energy used 110,311 TJ/yr. GHP has a progressive annual increase rate of over 27%, rather higher than the rest of the world. Figure 1 shows the process of GHP growth in China. The long series shows the statistics from Geothermal Council of China Energy Society (GCES); the short series shows the data from official web of Ministry of Housing and Urban-Rural Development (MHURD), which data consist of all heat pump including industrial waste water and urban sewage.

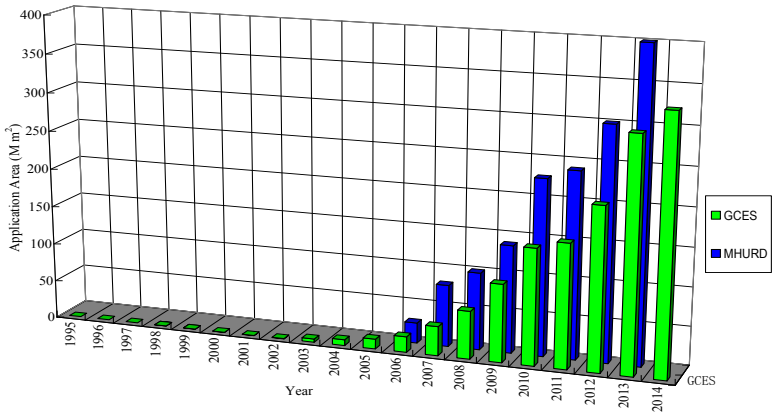

Fig 1 Growth of GHP application in China

Along with the GHP application fast growth, heat pumps and various ancillary materials become very large demand. Many heat pump manufacture enterprises established and expanded accompanying the GHP application. Off course, small factories for various ancillary materials making have expanded popularly. These large and small enterprises including installation companies have a total numbers more than 4,000 (Xu, 2013).

During the past 20 years, GHP industry in China has grown out of nothing and expanded rapidly. Relevant enterprises were organized into various societies and associations with nationwide, provincial and city size scales. Many media have participated in GHP industry with positivity even bigger. The monthly journal of "GSHP" founded in 2006 have vast readers. It issues 40,000 copies with 140 pages for each issue. The nationwide high-rank forum for GHP industrial was organized every year. The Top Ten Enterprises have been appraised and elected for 5 times annually. GHP industry appears flourishing complexion in China.

2. POLICY SUPPORT

Why GHP could get such high speed growing and last for so many years? The first is due to policy support from the national and local governments. The "Law of Renewable Energy of P. R. China" was issued in 2006. GHP was encouraged in the Law. Beijing government issued the "Guidelines on Developing GHP System". It expounded the government will pay subsidy for GHP application. So the greatest increase of GHP appeared in 2007. Shenyang implemented a leap plan and exceeded Beijing to become the first chair in the country. Ministry of Land and Resources hosted a nationwide experience exchange conference timely in 2007.

A series of governmental documents issued successively almost every years. Ministry of Land and Resources issued "Notification on promoting development and utilization of shallow geothermal energy" in 2008, and "Specification for shallow geothermal energy investigation and evaluation" in 2009 (Yang et al, 2010).

Ministry of Housing and Urban-Rural Development together and Ministry of Finance jointly issued "Implementation opinion on pushing renewable energy in building application" in 2006. The national policy provided special subsidy for selected projects, in which GHP occupied about a half of these projects. Thereafter the policy was extended for "Demonstration County of Renewable Energy" from 2010. Since 2012 it was extended further for "Demonstration Smart City of Renewable Energy". These policies promotes for renewable energy building application, especially GHP got largest support in which. As the result totally, 291 projects, 21 cities, 52 counties, 3 districts and 10 towns have been supported (Xu, 2013).

A new policy support issued in 2013. National Energy Administration, Ministry of Finance, Ministry of Land and Resources, and Ministry of Housing and Urban-Rural Development jointly issued a document "Guidelines on Promoting Geothermal Energy Development and Utilization" in January 2013 (NEA, 2013). To the end of 12th Five-year-plan in 2015, ground source heat pump application will reach 500 million squire meters; installed capacity for geothermal power generation will reach 100 MWe; total used geothermal energy will be equivalent to 20 million tons standard coal. Meanwhile the guidelines give some preferential policies for geothermal, including GHP projects (NEA, 2013).

3. NATIONAL INPUT

The GHP application may contain risk in inaptitude locations. In order to reduce such risks the Ministry of Land and Resources (MLR) has supported a huge project for 287 prefecture-level cities for investigation and evaluation of shallow geothermal energy, which mainly organized by each province (region, city), promoted by cooperation of province and Ministry of Land and Resources. The fund has spent for over 100 million CNY (about 16 M $ USD). The first demonstration was in Tianjin city to carry out the pilot work, uniform the methods and techniques. Secondly, based on the experiences obtained from the pilot work in Tianjin, spread this work to the other cities. Based on the identification of shallow geothermal energy storage condition, the suitable, basic-suitable and unsuitable areas for GHP development were shown in reports and maps. These achievements have been provided to local governments for application in further GHP projects. Figure 2 is such result from Beijing achievement. It shows the best, good and poor conditions (divisions) for GHP application of water type and soil type respectively.

The national project of investigation and evaluation of shallow geothermal energy had showed great potential. It provides heat capacity for GHP use. The total potential is equivalent to 9.486 billion tons of standard coal (Wang et al., 2013).

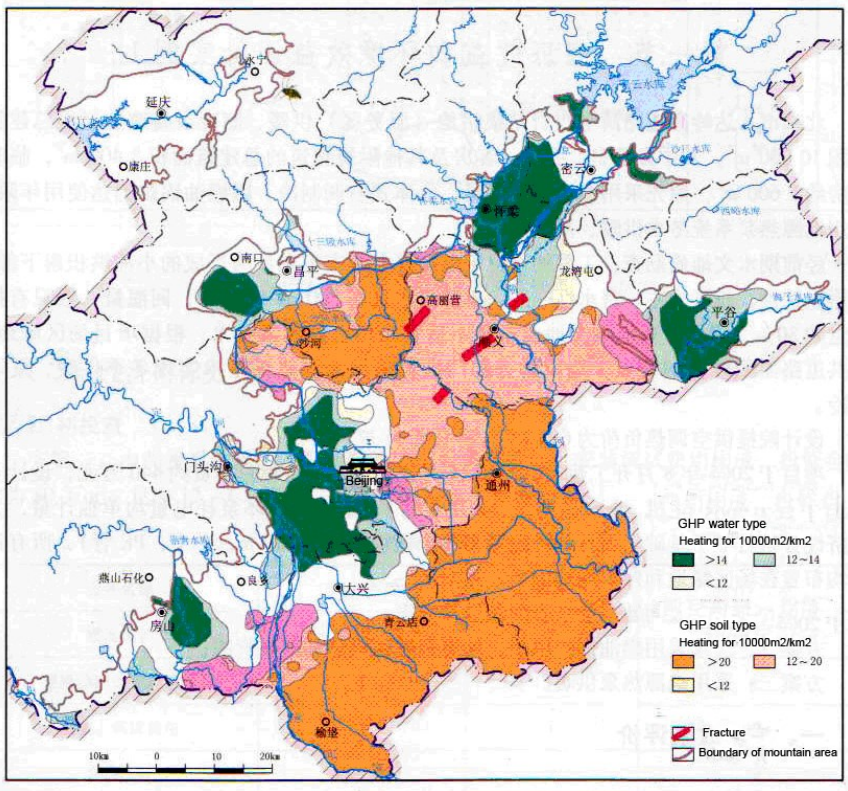

Fig 2 Division map showing suitability for GHP (water and soil types) in Beijing

4. GOVERNMENT'S ACTION

The rapid growth of GHP is not spontaneous events by the masses. There is government's action which is indispensable within all process of GHP development. Why GHP had a continuous increase of 15 million m^2 per year in 2007-2009 in Shenyang? That is the mayor of Shenyang assigned index for each district and signed the Letter of Assurance with each district leaders. Therefore these district leaders have to organize relevant force to complete their target. That is why Shenyang completed the GHP application of 15 million m^2 each in 2007-2009. Meanwhile, the GHP Management Office founded in Shenyang, uniquely in the country (Zheng & He, 2011).

In addition, the MLR's project for investigation and evaluation of shallow geothermal energy in Tianjin got support from Tianjin municipal government for sharing research fund. And the "Warm winter and cooling summer" project in Wuhan was the Wuhan municipal governmental decision. Therefore the government is important role in GHP growth in China.

5. EXISTING PROBLEMS

Along with the rapid growth of GHP market and the fast expansion of GHP industry, it is inevitable that something wrong occurred.

5.1 A Few Weak Design And Construction Teams

Accompanying with the great GHP market demand, initial design institutes and construction teams had not ability to bear so huge tasks. Big lack of market made new companies to involve the works. For example, new bosses established new companies to carry on new projects, but they came from various businesses including such boss sold wine before. Another problem is such new companies were lack in professional technicians. Some of new companies employed professional experts and engineers to train their staffs. However, many new companies and construction teams have not sufficient technicians and relevant qualifications.

5.2 Improper Matching Between Surface and Subsurface Installations

Some disfigurement projects were founded. They are mainly caused due to improper matching between surface and subsurface installations. The heat pump specifications are visible. The main reason is hydrogeological condition at the project site. It is because insufficient hydrogeological data. It will be no problem if ask hydrogeologists to understand hydrogeological conditions.

5.3 Weak Thermal Response Test and Modeling Prediction

Sweden owns most GHP projects in the world. Overall completed GHP projects have been running successfully in Sweden. Thermal response test has to be carried out at the project site. Then modeling prediction will confirm the design or adjust it. Such steps are important but it is weak in China. Site thermal response test was carried out in less projects only. Modeling calculation is lacking usually. Most of projects rely on past experience to draw design.

5.4 Who Is The Competent Authority

It is still not clear that who would be the competent authorities. GHP had a greatest growth in Shenyang, because Shenyang established the GHP management office. So everything concerned to GHP can be solved easily by the office, including plan application, examining and approving, implementation and inspection etc. However the status for most of cities is mult-authorities for concerned management.

6. CONCLUSIONS

Geothermal heat pump has a great development in China. It was actually started in 1995 with the first project of GHP heating and cooling application completed in Beijing. During the past 20 years, GHP industry in China has grown out of nothing and expanded rapidly. Geothermal heat pump application has reached 330 million m^2 in China in 2014. Its used capacity will be 11.8 GWt and with annual energy used 172,603 TJ/yr. GHP has a progressive annual increase rate of over 27% in recent years. Further progress has been drawn up. At the end of the 12^{th} Five-year-plan in 2015, Chinese GHP will reach 500 million m^2 of building area. It is equivalent to 17,850 MWt of used capacity and 151,987 TJ/yr of annual energy used.

The great progress is supported by national policies and financial subsidy. Even the GHP industry is not so large like wind and solar energies, but it will contribute a certain potential for energy saving and emission reduction in China.

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