THE POSSIBLE ROLE OF GEOTHERMAL ENERGY TO THE CHINESE ENERGY DEVELOPMENT

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ABSTRACT

Geothermal utilization as energy resource use has been for near 40 years in China. The used geothermal energy in whole country's energy structure is less than 0.3%. Geothermal power generation and geothermal direct use were carried out in China. The professional expert's crew and corresponding industrial base has founded. There are relative rich geothermal resources in China. Based on conventional geothermal development, GSHP has had rapid growth in recent years, and EGS has been studied also. It is expected that geothermal would make contribution to energy construction in China. At least we would prepare ready for certain energy reserves to our future children.

Keywords: geothermal energy, China, power generation, direct use, GSHP, EGS

1. MISINTERPRET OF THE "ICING ON THE CAKE"

Hot spring bath and medical treatment have had long historical record over two thousands years in China. Geothermal as energy resource utilization started basically in 1970. At that time, world's first crisis of petroleum price induced that many country governments started to pay attention to new energy development. Prof. J.S. Lee, the Minister of Geology called upon to use geothermal energy in China. He said that geothermal is a new energy in human history, and is a new domain for geological work. Under the times of planning economy, geothermal exploration in Beijing gained advice and deepened research from professors and researches; geothermal comprehensive use in Tianjin also gained such support. Professors and researches designed and advised geothermal practices. Such combination among production unit, university and institute created full success. Seven medium-low temperature geothermal power plants and Tibet Yangbajain high temperature geothermal power plant all completed in 1970s. Various geothermal comprehensive utilizations ran successfully in Fujian and Guangdong coastal areas. But, geothermal at all is a new business. Such initial projects include simplified and humble assembly and material. There were some shortcoming such as low efficiency, geothermal corrosion and scaling problems. For above medium-low temperature geothermal power plants, five of them ran for several years only. They were stopped by equipment aging. Similar problem caused low tide of geothermal utilization in 1980s. At that time, somebody said that geothermal was "icing on the cake", which means geothermal likes excessive decoration ---- unnecessary. And also somebody said: No working with geothermal, move to working with environmental protection.

In fact, the "icing on the cake" is historical misinterpret. Even at that time, the Yangbajain geothermal power generation made great contribution for the power supplying in Lhasa city. Geothermal space heating in Beijing and Tianjin saved a lot of coal, and reduced air pollution. Geothermal greenhouse planting and aquaculture feeding all created high economic value and served social demand. Hot spring bath and medical treatment increased people's health and improved people's living condition. The geothermal used energy in China is the first place in the world. Chinese geothermal utilization made significant contribution.

2. GREAT PROSPECTS OF GEOTHERMAL POWER GENERATION

The earliest geothermal power generation in China is installed in Dengwo of Fengshun county, Guangdong province. Geothermal water with 92°C temperature generated 86 kW electricity at the beginning. The Minister of Geology sent

telegraph as congratulation. At later, a 300 kW geothermal power station had been running there until 2008. In 1970s there were 7 such medium-low temperature geothermal power stations ran successfully. Except above one, the others are 300 kW Huitang of Ningxiang county in Hunan province, 200 kW Houhaoyao of Huailai county in Hebei province, 300 kW Tangdongquan of Zhaoyuan county in Shandong province, 200 kW Xiongyue of Gaixian county in Liaoning province, 200 kW Reshuicun of Xiangzhou city in Guangxi province and 100 kW Wentang of Yichun county in Jiangxi province. Even though they had only small installed capacity of total 1.6 MW, however they are Chinese independent achievement. No exported equipment. No foreign expert. The used flashing method and binary circulation method are the same technology as in the world.

In addition, high temperature geothermal steam power generation got success in Yangbajain of Tibet in 1977. The initial installed capacity is 1,000 kW. Then others 8 units with 3 MW each were installed later. It completed total installed capacity 25.18 MW in 1991. Geothermal electricity satisfied power supply in Lhasa city for 40% at the summer and 60% at the winter at that period. Up to date, Yangbajain power station still run over 6,000 hours and generates about 120 GWh per year.

In recent some 20 years, there was almost no increase of geothermal power generation. Chinese geothermal power generation is listed the 15th position for installed capacity and the 14th position for annual generated electricity. Why it had not progress? There was a misplay in Chinese geothermal trade. Even geothermal experts said that medium-low temperature geothermal power generation was feasible technically, but infeasible economically. This is a historical bias in fact.

Under present status of promoting renewable energy use, solar PV installation cost is 100,000 CNY for per kW, but it has been growing in many projects. However, the installation cost for medium-low temperature geothermal power generation is 10,000 CNY for per kW only. It is never “infeasible economically”. There are richer high temperature geothermal resources in China. According to exploration and detailed survey completed in Tibet, high temperature geothermal resources have a potential of 137.5 MWe installation capacities. The production well ZK4001 in Yangbajain geothermal field has working pressure 15 bars, working temperature 200°C, two phase flow 302 t/h and including steam flow of 37 t/h, therefore its single well potential is 12.58 MWe. In addition, by reconnaissance data estimated the geothermal resources potential is 299 GWe in Tibet. Except these, there are rich medium-low temperature geothermal resources in China. At least, we can use medium temperature geothermal resources for power generation as the first step, and then the used thermal water can be still used again for comprehensive utilization. This cascade utilization will fully use geothermal energy to bring into further play. Geothermal power generation will also contribute to the reduction of CO_2 emission.

Fig. 1 1,000 kWe screw-expansion engine installed in Yangbajain geothermal power station in Sep. 2008

We have had experiences for 30 years in binary circulation method for medium temperature geothermal power generation. We also developed the technology on screw-expansion engine application in geothermal power generation. Such an installation of screw-expansion engine with 1,000 kWe capacity has been installed in Yangbajain power station by using the discharged waste thermal water of 80°C. It has been taken dynamic debug.

3. CONVENTIONAL GEOTHERMAL COMPREHENSIVE USE

Hot springs distributed in every provinces in China. Geothermal resources stored in large and medium sedimentary basins in plain regions. Chinese used energy for medium-low temperature geothermal resources is the first place in the world. Geothermal direct use includes space heating, greenhouse planting, aquaculture feeding, industrial and agricultural use, bath and medical treatment, and relaxation and health health preservation etc. aspects.

Geothermal district heating is the best utilization for low temperature geothermal resources with little less than 90°C. Geothermal district heating in Tianjin occupies 70% of the whole country's geothermal heating. It increased almost 1 million m^2 per year recently. Geothermal district heating in Xianyang, Shaanxi province owns the second place. It increased almost 0.5 million m^2 per year recently. In addition, the Xiong county (Hebei province) geothermal district heating project, which got support by the Asian Development Bank loan, is implementing to increase 1.1 million m^2 heating. The annual growth of geothermal district heating is about 10%.

Traditional hot spring bath and medical treatment own a half capacity of geothermal direct use in China. In recent years, hot spring bath has risen into health care and relaxation progressively. The increased service items and quality have raised humanism and the culture of hot spring. Various hot spring resort, hot spring conference centre, hot spring health preservation garden and hot spring paradise etc. new projects debut year by year in Beijing, Tianjin and costal region. These attracted more consumers to enjoy comfortable life. Proprietors gained money from the operation. It made a good circulation for further growth. The Chinese Hot Spring Forum held close by the famous ancient Huaqing Pool hot spring in Lintong of Xi'an city last winter. Hot spring bath was added new content of hot spring culture. It made the local hot springs increased higher rank and economic benefit.

There is not significant increase in geothermal greenhouse planting and aquaculture feeding. But small growths can be seen in many places. The Asian Development Bank loan supported the geothermal comprehensive use project in Ningcheng of Inner Mongolia has been approved. It focused in geothermal district heating for new 160,000 m^2. But the circulated thermal water will be used for greenhouse and aquaculture. They planned to create hot spring relaxation and tourism also, in order to enlarge local geothermal economy.

Geothermal still has small utilization in textile and light industries techniques. Agricultural products can use geothermal drying. And geothermal water also can be bottled to produce mineral water.

4. HEATING/COOLING USING SHALLOW GEOTHERMAL ENERGY

Ground source heat pump (GSHP) is used to extract shallow geothermal energy for winter space heating and summer cooling, and provide hot water supply to buildings. This is a new industry with very fast growth in recent some 20 years. It is also a new domain for geothermal development.

It has been recognized popularly that GSHP could save energy, increase efficiency and reduce CO_2 emission. Such shallow geothermal energy can be used everywhere. Its developing cost is much lower than conventional geothermal resources. Therefore, both the GSHP installed capacity and used energy have a significant very fast growth in the world, especially in U.S., north Europe and west Europe. Since 1995, its average annual increase has been reaching over 20%. The world's authorized experts have predicted the further prospects: It would keep an annual increase of about 22% until 2020. Then the annual increase rate would decrease into 10~9% progressively. But its increasing numbers would still show a steep rising curve. GSHP has a long history for research in China. But actual application started at the time of entering the 21st century. However, a rapid growth started in 2004. There was an engineering building area of 7.67 million m^2 of GSHP in 2004. It reached into 20.35 million m^2 in 2006 and 38.00 million m^2 in 2007. Its installed capacity equals about 1,900 MWt. This number has entered the top five countries. The rank is U.S., Sweden, Germany, France and China. Follow the present speed and programming, China will enter the top three countries soon.

GSHP has proper application condition in the North China. There will be 4 months for winter space heating and 2-3 months for summer cooling. So Beijing has a bigger application. And Tianjin has a similar situation they used GSHP to heat circulated conventional geothermal water after heating use. The biggest GSHP application in China is in Shenyang city. The winter heating there needs for 151 days but summer cooling needs for about 30 days only. Rely on the promoting by the city government, it is stipulated that new building has to use GSHP, and old buildings were planned for reform using GSHP. Due to the very good hydrogeological conditions in Shenyang, it provided relative lower cost and simpler techniques. Thus GSHP increased 15 million m^2 building area in 2007, and has planned a new increase for 17 million m^2 in 2008, 2009 and 2010 respectively. In the East China, based on poor coal resource, increased coal cost and environment pollution problem, plus the air-conditioner heating at winter was destroyed at all in 2008 spring frozen disaster, therefore the GSHP has become the best choice now.

The XXIX Olympic Games held in Beijing 2008. The National Stadium (Bird's nest), National Swimming Centre and National Gymnastics Hall etc. and Olympic Village etc. new buildings, all used GSHP partially for cooling, space heating, hot water supply and sight water etc. aspects. The GSHP applied energy is 26% of total building energy consumption. GSHP contributed to the "Green Olympics" which Chinese promised.

Fig. 2 Beijing Olympic National Stadium (Bird's nest) used GSHP partially

5. STUDY ON ENGINEERED GEOTHERMAL SYSTEM

The hot dry rock (HDR) is called as engineered geothermal system or enhanced geothermal system now. The research report named "The future of geothermal energy" was submitted from the Massachusetts Institute of Technology in this year. The report aroused astoundment of US Department of Energy. The subtitle of the report is called "Impact of enhanced geothermal system on the United States in the 21rt century". In order to face the population increase and the growth of social electrification, and to consider security of energy supply and confront the economical instability induced by oil price undulation or supply breakdown, this report was requested to answer that if geothermal energy could provide 100 GWe base capacity of power generation in 2050. The research result showed the EGS is possible to provide such electric power and heat energy. The EGS is native land resources. It is not like the hydrothermal type high temperature geothermal resources which restricted by certain geological condition. This clean energy will cause smallest environmental impact. It can be invested and developed in reasonable budget to get superiority of running cost. This technology will be solved within 10-15 years. The report estimated the EGS resources in US are over 13 million EJ. The exploitable energy is 200,000 EJ. This equals to 2,000 times of base energy consumption in 2005.

EGS has a research history over 30 years in the world. But it is limited in US, UK, France, Germany, Japan and Sweden. A few Chinese research papers discussed this topic before. But no actual activity carried out. However, Geothermal China Energy Society (GCES) signed a cooperation contract with Australian Petratherm Ltd. in 2007. The cooperation

project is named that the research on resources potential of EGS in China". In 2008 both Chinese and Australian experts have investigated in some potential areas. Further tests analyses and modeling research has been undertaking. For next year's plan, advanced geophysical survey such as MT sounding will be carried out. Then exploration well will be drilled in 4,000-5,000 m depth. The expected temperature is predicted as high as over 200°C. The well diameter will reach 8"4'. Then various tests and measurement will continue. China Geological Survey also supported fund in this project.

6. SUMMARY

Chinese ancestors had recorded hot spring use since 2,000 years ago. Hot spring resource exploration and assessment were carried out from 1950s. Chinese started geothermal utilization as energy resource use in 1970. Under the Planned economy, the first time of geothermal development raised a high tide. Geothermal resources were discovered in Beijing Urban area and other cities. Geothermal comprehensive direct use and power generation occurred throughout the country, especially in Tianjin. At later, along with the reduction of national investment in 1980s, the low tide of geothermal development was misinterpreted as unnecessary. However, passing through the aids of United Nations project and international geothermal exchanges, Chinese geothermal workers learned advanced experiences and understood own liability for geothermal new energy and renewable energy. Based on richer geothermal resources in China, various geothermal utilizations were taken practice.

Geothermal power generation has been delayed for 30 years due to the error viewpoint about "feasible technically and infeasible economically". Now we have recognized the feasible value in commercial competition. We will restart its growth.

Geothermal comprehensive use is geothermal district heating mainly. Rapid growth occurred in Tianjin and Xianyang. Hot spring bath and medical treatment have increased humanism to transfer into health care and relaxation. It gets favour from consumers. And it also promoted development of geothermal market.

GSHP saved energy and reduced emission of CO_2. It is suitable for everywhere. Its running cost is lower. Shenyang, Beijing and Tianjin showed a very fast growth. It has occupied one third of used energy in geothermal direct use. 2008 Beijing Olympic Games used GSHP partially (26%) in many competition halls and stadium.

Since last year, China has taken part in research for engineered geothermal systems (EGS). This is a preparation of resources reserves for our future children.

The used geothermal energy in whole country's energy structure is less than 0.3%. But there are relative richer geothermal resources in China. The main sedimentary basins in China reserved geothermal resources of 73.61×10^{20} J. It is equivalent to standard coal of 250×10^{9} t. We are able to exploit 50×10^{9} tons of them. According to geothermal exploration and detailed survey, there are 6.845×10^{9} m^3 of geothermal water as resources could be exploited. It contains total heat of 972.68×10^{15}J. It is equivalent to 32.847 million tons standard coals.

China has owned ability to undertake geothermal power generation and geothermal direct use, including geothermal district heating, greenhouse planting, aquaculture feeding, industrial and agricultural use, bath and medical treatment, and relaxation and health reservation etc. aspects. We have experienced expert's crew and rather industrial base. On the bases of conventional geothermal development, GSHP has had rapid growth, and EGS has been studied also. It is expected that geothermal would make more contribution to energy construction in China. At least we would prepare ready for certain energy reserves to our future children.

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