GEOTHERMAL ENERGY IN DEVELOPING COUNTRIES ——PROSPECTS AND PROBLEMS, CASE HISTORY FROM CHINA

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ABSTRACT

Geothermal energy may play an important role in energy-supply for developing countries. In China. Yangbajing geothermal power plant with installed capacity of **25.8** *MW* supplies about **41%** (more than 60% in the winter time) of needed electriricity to the Lhaa city. the capital of Xizang (Tibet) Autonomous Region. Low-medium temperature thermal water resources are quite | abundant in large sedimentary basins of eastern and central China and are being used for various non-electrical purpose. In this paper. the prospects and problems of development and utilization of geothermal energy in China are discussed and analyzed in detail by the author.

KEY WORDS: Geothermal energy; Developing countries; Prospects; Problems: Case history; China

INTRODUCTION

Geothermal energy may play **a very** important **role** in the energy supply far developing countries, especially for those countries which are suffering shortages of conventional energy (oil, gas. coal) but are rich in geothermal resources. Philippines could **be** regarded as a “typical” country of this sort. For instance, **92%** energy supply of the Philippines depended on imported **oil** and gas in **1973.** *To* reduce the impact of the Middle East oil supply crisis at that time, the Philippines goverment launched a comprehensive energy development program to make the country self reliant in its energy requirements and less vulnerable to foreign oil supply. **As** a result, imported energy had been reduced to a more manageable level of **55%** by 1985, and geothermal energy comprised **15.5%** of the total installed power plant capacity in

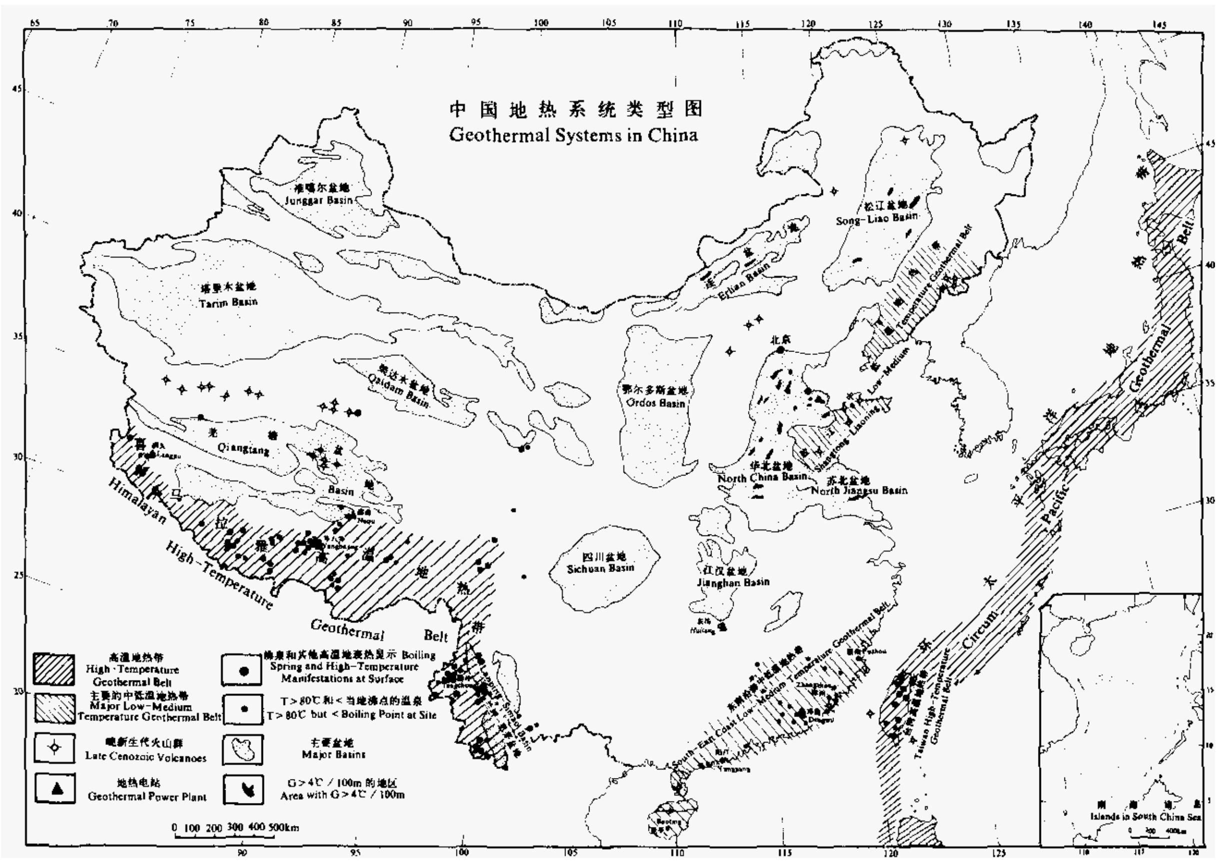

Fig. I Geothermal systems in China

Philippines. The abundance of geothermal energy in Philippines makes it the most promising among various indigeneous energy–sources. The total installed capacity of geothermal power plant was 888 MW in 1992 which accounted for 20.74% of the total power generation mix in Philippines. The estimated increase of geothermal contribution is from 20.74% in 1992, to 25% in 1996 and, finally, to 32% at the end of the century in 2000 (Sarmiento, 1993).

In China, use of geothermal cncrgy started in the early 1970's. Although the total installed capacity of geothermal power plant only accounts for a tiny percentage (< < 0. 1%) of the total power generation for the whole country. it still makes great sense for the vast remote area of SW China. For instance. a geothermal power plant with installed capacity of 25.18 MW was set up in the Yangbajing geothermal field which supplies about 41% (more than 60% in the winter time) the electricity for the Lhasa city, the capital of Xizang (Tibet) Autonomous Region nowadays. Two other geothermal power plants (Langjiu and Naqu) have been installed in Tibet with the hope of helping solve energy–shortage problems in this remote area. In Tengchong volcanic area, to the west of Yunnan Province. on the border with Burma. there also exist abundant high–temperature geothermal resources and the local gaverment is very much interested in using these indigeneous resources for powcr generation.

Another reason for encouraging utilization of new and renewable (including geothcrmal) energy in China comes from the global concerns about environment and development for **all** mankind. It is well known that "China has a coal-based energy structure. with coal consumption amounting to 75% of total energy consumption. Clcaner energy constitues only **a** small proportion of the total energy supply. Because of this, there are emissions of large quantities of pollutants, resulting in serious atmospheric and water pollution." (China's Agenda 21, 1994).For this reason, some activities and measures have been taken to give priority to the development of new and rcnewable resources in the national energy development stratcgy and a "Nation –wide Project on the Development of New and Renewable Energy for the period 1995–2010" is under way. This is good news not only for China but also for the whole world.

PROSPECTS

1. Resources

It is obvious that resources are the basis for geothmal energy development. It can be seen from Fig.1 that China has quite abundant geothermal **resources** all **over** the country with high temperature ones concentrated in Himalayan Geothermal Belt of SW China and Taiwan in the East. The total capacity of geothermal power generation for the whale Himalayan Geothermal Belt amounts to 1740 MW. of which 1000 MW has been estimated for S. Tibet, 570 MW far West Yunnan and 170 MW for West Sichuan Province (Chen et al.,1994). The estimated potential for power generation in the Datong (Tatun) volcanic area of Taiwan is about 100 MW (Chen,1989). Great numbers of potential geothermal resources for non–electrical, direct use exist in the large–scale sedimentary basins in eastern and central China. They include: Song–Liao, Lower Liaohe, North China. Northern Jiangsu, Fen–Wei, Ordos, Sichuan. Leiqiong and Chuxiong Basins. The thermal energy in recoverable wafer resources contained in these basins equals 1.854 billion tons standard of coal. In addition to the afore–mentioned two types of resources, there exists another type of geothermal energy, i.e. low–medium temperature thermal water resources from convective geothermal systems which are concentrated in the **SE** coastal area and the E. Shandong–E. Liaoning Peninsula. Altogether 26 systems with temperatures > 80°C occured in **SE** coastal area (Fig.1) It must be noted that most likely in China there also exist so–called geopressured geothermal resources in Ying–Qiong Basin of South China Sea to the SW of Hainan Island and li–Yang Depression of North China Basin. The energy potential of these resources must be considered to be huge and furhter studied plus resources assessments are needed.

2. Demand

As mentioned before. the energy-shortage problem is vcry serious for remote areas of SW China, especially for Tibet, because there is no conventional energy source at all. The only indigeneous energy–sources which can be used are hydro–power and geothermal energy. The hydro–power suffers seasonal fluctuation because in Tibet, the weather is severe in the winter time and the water in most **rivers** and lakes is frozen. Besides, "water" in Tibet is regarded as a God just as "fire" (volcano, geothermal.……) in Hawaii is treated by local natives as a God. Therefore. the Tibet people prefer to use geothermal energy rather than water power. There are 21 counties having no electricity at all which accounts for 28% of the total number of counties (74) in Tibet. However, in southern Tibet alone, there are more than 600 hydrothermal manifestations at the earth's surfaces. It is believed that using this geothermal energy for power generation may play an important role in reducing the number of the so–called "No Electricity Counties" (Fig.2). Low–medium temperature geothermal resources are widely used in eastern and central China for non–electrical purposes such as space heating, green houses, fish farming, agriculture, aquaculture and industrial processing. There still appears growing demand for direct **use** of geothermal resources for saving conventional energy–source and for upraising the living standard of people. Currently, there are 594 thermal water baths, 23 hat water swimming pools and 179 sanatoriums with many more **local** pools at hot spring sites. The famous training center for the female valleyball team using thermal water is located in Zhangzhou City, Fujian Province (Fig.3).

3. Policy

In recognizing the environmental problems and the inenvitable trend of replacing conventional energy-sources by new and renewable energy resources with time, the Chinese goverment encourages the reseach and development of new and renewable energy nation–wide and some actions have been attemped. In currently published " China's Agenda 21 --- White Paper on China's Population, Environment, and Development in the 21st Century" adopted at the 16th Executive Meeting of the State Council of the People's Republic of China **an** 25 March, 1994. it was clearly stated as fallows:

1). "Give priority to the development of renewable energy **sources** in the national energy development strategy. Adopt appropriate financial incentives and market mechanisims to increase national financial inputs into the development of renewable energy resource and to encourage the participation of **local** goverments and end–user " (13.57 from "China's, Agenda 21");

2). "Conduct a nation–wide investigation and assessment of geothermal resources. Build geothermal stations. In the process of developing geothermal **resources,** protect the environ-

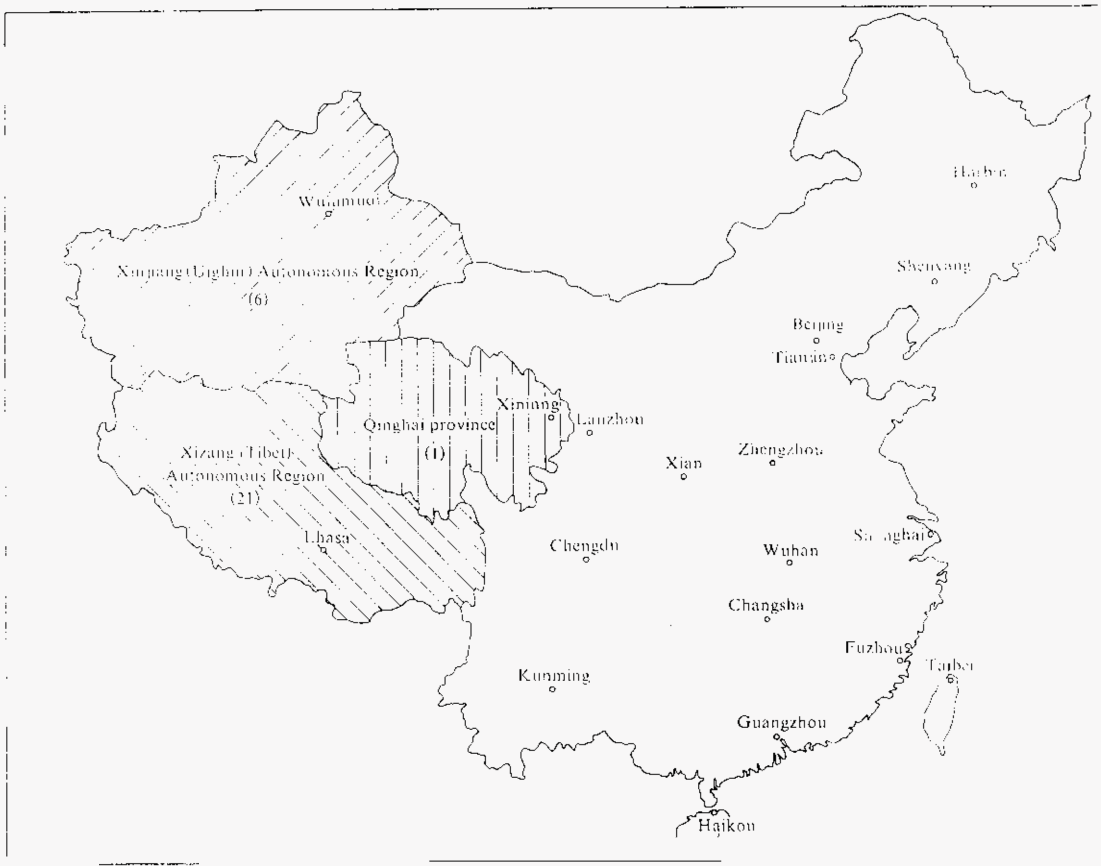

FIG. 2 Distribution of "No Electricity Counties" in China (Shaded zone represents "No Electricity Counties" distribution area with county numbers **in** parenthesis)

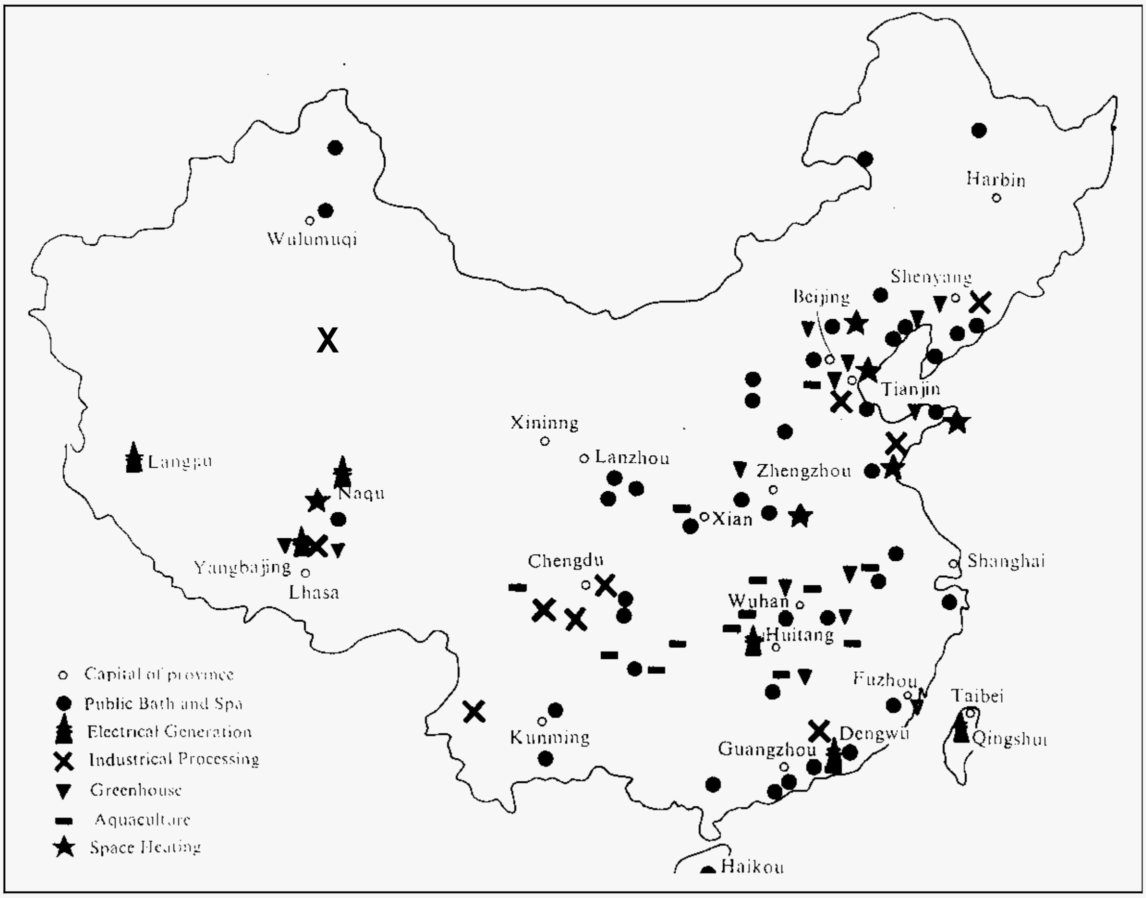

FIG. **3** Geothermal utilization sites in China (modified from Ren **and** Tang, 1989) ment against adverse impacts" (13.57–e from "China's Agenda 21");

3). "Keep up with scientific and technological advances in the world. Strengthen research on technologies for utilizing new and renewable energy resources.... Introduce advanced foreign technology, improve research conditions, and enhance the research capabilities of scientific researchers" (13.58 from "China's Agenda 21");

4). "International cooperation in this programme area will include the use of foreign capital and technology to conduct research on and build demonstration projects for the development and utilization of new and renewable energy resources" (13.59 from "China's Agenda 21");

It is clear that the above–mentioned actions will promote the research and development of new and renewable energy in China greatly.

4. International cooperation

It must be pointed out that the rapid development of geothermal energy in China seems to be impossible without outside assistance and international cooperation. In the last decade, United Nations Development Program (UNDP) has supported geothermal development projects in Beijing. Tianjin area and Yangbajing geothermal fields. Recently, a geothermal power plant with capacity of 1.0 MW using ORMAT Energy Conveter (OEC) was set up to generate electricity from thermal water of 110°C in Naqu. Tibet to the NE of Lhasa city. The project was originated by UNDP and the contract, after an international tender. was awarded by the United Nations. The power plant is the highest of this type in the world (at 4500m above sea level) and was commissioned in November. 1993. Since 1988, the International Atomic Energy Agency (IAEA) has supported a research project on the application of isotope and geochemical techniques in geothermal exploration for the Zhangzhou geothermal field, Fujian Province. Now, the target area has been extended to geothermal areas of Guangdong, Hainan Provinces in SE China. During the period 1980–1995, many Chinese experts were trained in the UNU Geothermal Training Programme at ORKUSTOFNUN in Reykjavik, Iceland; the UNDP Geothermal Diploma Course at Geothermal Institute of Auckland University, New Zealand; the UNESCO Group Training Course in Geothermal Energy at the Research Institute of Industrial Science of Kyushu University, Japan and the UNESCO Course in Geothermal Exploration at the International School of Geothermics in Pisa. Italy. These geothermal training programmes and/or courses are sponsered by U.N. organizations with part contribution from the host countries.

From the above–mentioned it is clear that the research and development of geothermal energy in China has benefitted from international cooperation and outside assistance very much.

PROBLEMS

1. Uneven distribution of geothermal energy and lack of accurate resource assessment. As clearly demonstrated in Fig.1, high–temperature geothermal energy is concentrated in Tibet. W–Yunnan and W–Sichuan Provinces along Himalayan Geothermal Belt. The estimated potential for power generation is about 1740 MW which only equals about 2% of that in the United States. Although the estimated potential for power generation in the Datong (Tatun) volcanic area of Taiwan is about 100 MW, it seems very difficult to develop because the geotherrmal fluid is so acid (pH ~ 2.0) that it can not be used practically owing to the serious corrosion problems (Chen, 1989).

Low–medium temperature thermal water resources are quite abundant and widespread all over China in large–scale sedimentary basins. However, thermal water in basins from W–China such as Talimu (Tarim), Chaidamu (Tsaidam), Zungeer (Dzungar) etc. seems to less promising for direct use because the water quality is not so good and the salinity is too high (up to 30g / l). Furthermore, W–China is less populated and, in fact, there are no users for the vast desert areas except for a few big cities and towns. In this context, only thermal water stored in basins from eastern and central China may be used for various non–electrical purposes. It must be stressed that so far no accurate assessment on geothermal resources for the whole country exists. It is extremely urgent to start this work because the resources assessment serves as the hasis lor the development and utilization of geothermal energy. In addition to thermal waters and/ or high–temperature gcothermal fluids, resources assessments of geopressured gcothermal energy and hot dry rock are needed too.

2. Shortage of capital and invesment on geothermal exploration and exploitation

It is well–known that the investment in geothermal exploration and exploitation is very expensive and, sometimes, bears risks. At present. a 1500 m well would cost 5.35 million Chinese Yuan (RMB) in Tibet and W–Yunnan Province. The cost for installation of geothermal power plant has been estimated as RMB 6000 / kw for Tibet and RMB 5000 / kw for W–Yunnan. The total invesment for power generation in Tibet and W–Yunna by the ycar 2000 amounts to RMB 400–600 million according to the "Program and Forecast on the Geothermal Power Generation Development in China" (Ren et al., 1995). Large amounts of money arc needed. It is obvious that China seems to be not able to invest by herself alone. In this context, foreign capital and investment are most welcome. There would be two options: foreign capital investment and / or joint venture in the farm of B.O.O. (Build. Own, Operate) or B.O.T. (Build, Operate, Transfer). Preliminary economic analysis showed that if a 10 MW geothermal power plant is taken as an example, the time for invesment recovery will be more than 5 years in Tibet and no more than 5–6 years in W–Yunnan (Ren et al., 1995).

3. Technical aspects of geothermal energy utilization

Corrosion and scaling are two common problems in geothermal exploitation and utilization. In the Yangbajing geothermal field, these problems are especially serious and they must be solved urgently. For geothermal energy development and utilization, reservoir engineering is very important and reinjection of the used fluid back into ground is needed for both purposes of saving resources and environment protection. Unfortunately. studies in reservoir engineering are very weak and in most cases, there is no reinjection at all. For non–electrical utilization of geothermal energy, technology on heat exchange, and heat transfer are of significant importance. Although some research on heat exchangers and heat pumps were started in China, they still need application and transfer into industrial production.

CONCLUSION

Geothermal energy played and continues to play an important role in solving energy–shortage problem in the remote area (Tibet, W–Yunnan and W–Sichuan Provinces) of SW China. This is due mainly to the good match of sparse conventional energy–source and abundant geothermal. Low–medium temperature geothermal resources are quite abundant in large–scale sedimentary basins in eastern and central China. These resources are mainly used far non–electrical direct utilization and show good prospects. In North China, thermal water has been widely used for space heating of big cities such as Beijing and Tianjin. In the vast country sides. thermal water is mainly used for greenhousing and fish–farming because the weather in the winter time is very cold. Hot spring water has also been used far baths, spas, swimming pools and sanatoriums. In recent years. there appears a increasing demand for hot spring water for recreation and for even luxury purposes with the improvement of people's living standard. In recognizing the inevitable trend of energy–source transfer and the importance of environment protection. policy in favor of the development of new and renewable (including geothermal) energies has currently been formulated and clearly stated in the "China's Agenda 21——White paper on China's Population. Environment, and Development in the 21st Century". International cooperation and outside assistance has promoted and stimulated the development of geothermal energy in China greatly. Both technology and capital from outside are needed. We are quite optimistic that the more rapid development in this area will continue because the "open" policy in China will last forever. Prospects are great but problems still remain. Challenge and opportunity emerged and co–existed at the samc time. We should face the challenge and grasp the opportunity to develop geothermal energy in our country more rapidly. This is our conclusion.

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