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THE ROLE OF UNU-GTP ON GEOTHERMAL DEVELOPMENT IN CHINA

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ABSTRACT

The Geothermal Training Programme of the United Nations University (UNU-GTP) in Iceland has been operating successfully for over 30 years since 1979, financed mostly by the Icelandic Government. There have been 402 scientists and engineers, mostly from developing countries that are with significant geothermal potential, trained in the programme till 2008. Since the MSc programme started in late 1990's, 15 UNU Fellows have got their MSc degree (incl. July 2008). In 1980, the first group of Chinese fellows participated in the training programme. Since then, 70 Chinese fellows have completed the 6 month specialized geothermal training in Iceland (including 2008 UNU Fellows), accounting for 17.4% of all the UNU Fellows. One Chinese fellow has also completed her MSc study in Iceland. Most of the Chinese fellows are from Beijing and Tianjin, where geothermal utilization is more extensive than other areas in China. The Chinese UNU Fellows are playing a very important role in the geothermal development in the country, and many of the former UNU Fellows have become leading experts in their specialties in different parts of the country. The contribution of UNU-GTP on the geothermal development in China has long been recognized.

1. INTRODUCTION

Geothermal is a kind of renewable and environmental friendly energy source that is used for power generation and various direct purposes. Geothermal resources have been identified in some 90 countries. Till 2004, there have been 22 countries using geothermal for power production, with 8,933 MWe installed capacity and 56,786 GWh electricity production annually; and there have been 72 countries making direct use of geothermal, with 28,268 MWt installed capacity and 75,943 GWh energy use annually (Fridleifsson, 2008a).

High-enthalpy geothermal in China only occurs in Tibet, Yunnan and Taiwan. The installed electricity generation capacity is 25.18 MWe in Tibet, accounting for 25% and 40% of the power supply for the City of Lhasa in the summer and winter, respectively (Zheng, 2008; Dor, 2008). There are abundant low-enthalpy geothermal resources in China, distributed in most of the cities, provinces and autonomous regions, used for space heating, green house farming, fish farming, bathing, health spas etc. Since 1990's, space heating use has been developing fairly fast in China, especially in the big cities in the northern part of the country, such as Tianjin, Beijing and Xianyang. On the other hand, use of shallow geothermal resources by means of heat pumps for heating and cooling has expanded tremendously in the past several years. Till 2004, direct use of geothermal energy in China amounted to 12,605 GWh/yr, with China continuing to be in the first place in the world (Zheng, 2008).

With the increasing awareness of CO₂ emission control, it can be foreseen that geothermal utilization in China will continue to expand in the future.

Since 1979, the Geothermal Training Programme of the United Nations University (UNU-GTP) has been operating at Orkustofnun - the National Energy Authority of Iceland, with great success. The aim is to assist developing countries with significant geothermal potential to build-up or strengthen groups of technical specialists that cover most aspects of geothermal exploration and development. The priority is given to candidates from institutions where geothermal work is already under way. All candidates are selected by private interviews. Candidates from developing countries and most Central and Eastern European countries have received scholarships (covering tuition fees, per diem and international travel) financed by the Government of Iceland (80%) and the United Nations University (20%). Upon completion of their training, the participants receive a UNU Certificate. In the past 30 years, 380 geothermal professionals have completed the 6-month training programme in Iceland and 22 are expected to be added to that number in 2008. Furthermore, 15 former UNU Fellows of the 6 month training have completed MSc studies with a fellowship from UNU-GTP (before end of July 2008) (Fridleifsson, 2008b).

In China, scaled geothermal use only started in 1970's. Hydrogeologists and petroleum geologists started the geological exploration for geothermal development. Geothermal expertise was badly needed in that time in China, both with regards to the number of professionals and geothermal knowledge. The opening of UNU-GTP in Iceland in 1979 gave the Chinese professionals a good opportunity to learn from countries with advanced geothermal knowledge. Now 65 Chinese fellows completed the 6 month specialized geothermal training in Iceland, and 5 more are undergoing training, and 1 Chinese fellow has also completed her MSc study in Iceland. In 11-18 May 2008, the first UNU-GTP workshop in Asia was held in Tianjin, as the first step of setting up annual courses in China, aiming at a) training of geothermal professionals with university degrees and b) training of technicians and operators of district heating systems.

Almost all the Chinese UNU Fellows have returned to their geothermal post when they completed their 6 month training and MSc study, and have been very active in the geothermal exploration, utilization and management. At present, over 40 fellows are still working on geothermal, while 13 fellows of the early years have retired, while about 10 fellows changed their professions. A number of the fellows have become leading experts in the geothermal community in China. On one hand, the UNU-GTP played a very important role in the geothermal development in China. On the other hand, it also promoted the cooperation and friendship between China and Iceland significantly.

2. OVERALL STATISTICS ON CHINESE UNU FELLOWS

Till October 2007, 65 UNU fellows from China HAVE completed the 6-month geothermal training courseS in Iceland since Mr. Yao Zu-jin and Mr. Zhou Xi-Xiang participated in the training in 1980 (Mr. Xin Kuide and Ms. Huang Shangyao had participated in a short training course earlier). The 65 Chinese fellows (accounting for 17.1% of all the 380 fellows) are from 15 cities, provinces and autonomous regions, including Beijing (19), Tianjin (19), Hebei (6) and Tibet (5) etc. (Figure 1). Of the 65 fellows, 11 are female, accounting for 18.5%. And one female Chinese UNU Fellow, Ms. Sun Caixia has completed her MSc degree in Iceland and returned to her previous post.

The Chinese fellows, who completed the 6 month training, have mostly specialized on Reservoir Engineering, Chemistry of Geothermal Fluids, Geothermal Utilization and Environmental Studies, while only 8 of the 70 fellows have specialized on Borehole Geology, Geophysical Exploration, Borehole Geophysics and Drilling Technology (Table 1) (Fridleifsson, 2008b). Recently, geothermal utilization and environmental studies are becoming more and more popular among Chinese UNU Fellows, while Reservoir Engineering and Chemistry of Geothermal Fluids are still quite common

specialties. This is because of needs for more geothermal utilization engineers and the increasing awareness of environment protection in China.

In China, there is still not available university education specializing in geothermal. A large part of the scientists working on geothermal are hydrogeologists, and some of them do not have knowledge of all the aspects related to geothermal. For instance, the reservoir engineers often have good understandings of the liquid movement, but lack of knowledge about heat transport in geothermal systems. Therefore, the UNU-GTP is a very good supplement and expansion to their geothermal knowledge. They also learn a lot of know-how from the teachers and their supervisors. For example, the computer programs LUMPFIT (Axelsson and Arason, 1992) and ICEBOX (Arason and Bjornsson, 1994) developed by Orkustofnun have been used in a lot of geothermal fields in China.



FIGURE 1: Number of Chinese UNU Fellows, who have completed the 6-month training in Iceland, from different cities, provinces and autonomous regions (Fridleifsson, 2008b)

TABLE 1: Specialties of the 70 Chinese fellows who have completed the 6 month training (including those being trained in 2008)

Specialty	Number of Fellows
Reservoir engineering	24
Chemistry of geothermal fluid	14
Geothermal utilization	15
Environmental studies	9
Borehole geology	3
Borehole geophysics	2
Drilling technology	2
Geophysical exploration	1
Total	70

Before China's opening up to the outside world in 1980's, there were not many who were able to speak English and any other foreign languages. This made it difficult for the Chinese geothermal community to communicate with international geothermal institutions. The geothermal training in Iceland improved the English ability of the Chinese fellows much, and they became more and more active in the international exchanges in geothermal. For example, the number of papers by the UNU Fellows accounted for about 40% of the papers presented by the Chinese authors in the World Geothermal Congress in Turkey in 2005.

Till now, 13 of the Chinese UNU Fellows before 1985 have retired (in China, the normal age of retirement for technical staff is: 60 for male and 55 for female). Although about 10 fellows from China changed their professions, more than 40 of the Chinese fellows are still working on geothermal and are playing quite important roles in various part of the country. A few of the fellows have become leading geothermal experts in China, such as Professor Huang Shangyao in the Geomechanics Institute of the CAGS (China Academy of Geology Sciences), Dr. Pang Zhonghe and Dr. Zhao Ping from the Institute of Geology and Geophysics of the Chinese Academy of Sciences, Ms. Wang Kun from Tianjin Bureau of Land, Resources and Real Estate management and Mr. Pan Xiaoping from Beijing Institute of Geological Engineering.

The UNU-GTP has been supporting China's geothermal development greatly in the past 30 years. The Geothermal Training Programme has also promoted significantly the cooperation and friendship between China and Iceland. Iceland enterprises played key roles in a number of geothermal projects in China, such as the geothermal heating projects in Tanggu, Tianjin, the geothermal heating project in Xianyang, Shaanxi, as well as the geothermal heating project close to the Olympic Green in Beijing. The UNU Fellows are often active in the cooperation. With the rapid growing of geothermal direct use in China, Icelandic enterprises will be involved in more and more geothermal projects in China.

3. UNU FELLOWS FROM BEIJING

From Beijing 21 UNU Fellows have completed the 6-month geothermal training in Iceland, including the 2008 UNU Fellows. Together with Mr. Xin Kuide and Ms. Huang Shangyao, who participated in a short course in 1980, there are 23 fellows from Beijing. The 4 fellows before 1985 have retired. Of the rest, 15 fellows are working in three institutions:

1. Institute of Geology and geophysics under the Chinese Academy of Sciences (CAS), including Dr. Pang Zhonghe, Dr. Zhao Ping, Dr. Hu Shengbiao and Dr. He Lijuan;
2. Beijing Institute of Geological Engineering (BIGE), including Mr. Pan Xiaoping, Dr. Liu Jiurong, Mr. Xu Wei, Mr. Sun Ying, Mr. Han Zheng and Mr. Guo Gaoxuan;
3. Beijing Institute of Geo-Technology (BIGT), including Mr. Yin Heng, Mr. Xu Youshi, Ms. Sun Caixia, Ms. Yu Yuan and Mr. Yang Quanhe.

Ms. Wang Wei is involved in a geothermal heating project in Xianyang, which is undertaken by a joint venture of Icelandic enterprise and Sinochem. The other three changed their professions (Table 2).

The 23 fellows from Beijing have made a lot of contributions to the geothermal development in China. Mr. Xin Kuide, formerly an important officer in the Ministry of Geology and Mineral Resources, did a lot in promoting the geothermal development in China. Although retired now, he cares a lot about China's geothermal and the UNU-GTP. Ms. Huang Shangyao has also retired officially, but she is still very active in geothermal research and publicity. She had a wealth of academic achievements, such as the "Map of Hot Springs in China". After working with the International Atomic Energy Agency for a few years, Dr. Pang Zhonghe came back to his previous post. He is one of the leading experts on radioactive technique application on geothermal research, and is in charge of a few projects of national level scientific research. Mr. Zhao Ping is well-known in the geothermal community in China for his research on the geothermal in Tibet and other part of China. Mr. Hu Shengbiao and Ms.

He Lijuan have also done a lot in geothermal research in various part of China. The UNU Fellows from BIGE and BIGT are playing leading roles in the geothermal exploration, utilization, management and protection in Beijing, especially the geothermal reinjection and geothermal heat pump use for heating and cooling. They are also involved in a lot of geothermal projects in other parts of China, such as the construction of “No Smoke City” by geothermal district heating in Xiongqian, Hebei Province.

TABLE 2: The situation of UNU Fellows from Beijing

Name	Year of training	Field of training	Work engaged in / Institution
Xin Kuide	1980	Short course	Retired
Huang Shangyao	1980	Short course	Retired officially, still working on geothermal
Tang Song-ran	1981	Drilling	Retired
Wu Liya	1984	Utilization	Retired
Pang Zhonghe	1988	Chemistry	Geothermal / Professor in CAS
Zhao Ping	1991	Chemistry	Geothermal / Professor in CAS
Wu Ming	1992	Res. Eng.	Non-geothermal
Hu Baigeng	1993	Res. Eng.	Non-geothermal
Hu Shengbiao	1994	Res. Eng.	Geothermal / Professor in CAS
Pan Xiaoping	1998	Chemistry	Geothermal / BIGE
Liu Jiurong	1999	Res. Eng.	Geothermal / BIGE
He Lijuan	1999	Res. Eng.	Geothermal / Professor in CAS
Yin Heng	2002	Utilization	Geothermal / BIGT
Xu Youshi	2002	Res. Eng.	Geothermal / BIGT
Zhang Yuandong	2003	Res. Eng.	Groundwater / Tsinghua University
Xu Wei	2004	Chemistry	Geothermal / BIGT
Sun Caixia	2005	Utilization/MSc	Geothermal / BIGT
Sun Ying	2005	Res. Eng.	Geothermal / BIGE
Yu Yuan	2005	Environment	Geothermal / BIGT
Wang Wei	2006	Chemistry	Geothermal / Sinochem
Yang Quanhe	2006	Res. Eng.	Geothermal / BIGT
Guo Gaoxuan	2008	Res. Eng.	Geothermal / BIGE
Han Zheng	2008	Res. Eng.	Geothermal / BIGE

4. FELLOWS FROM TIANJIN

Since 1983, there have been 21 Chinese UNU Fellows from Tianjin completing the 6 month geothermal training in Iceland (including 2008). Their academic backgrounds range from geology, hydrogeology, mechanical, and chemical engineering etc. There are 7 female fellows among the 21 from Tianjin, accounting for 33.3%. The 7 fellows before 1987 have retired, and 11 fellows are still working on geothermal in Tianjin, while 3 have moved to other countries. Among the 11 fellows working on geothermal, 6 are now with Tianjin Geothermal Exploration and Development Institute (TGEDI), and 3 are with Tianjin University, and 2 are involved in the geothermal management in Tianjin (Table 3).

After the training in UNU-GTP, combined with practical experience in geothermal, most of the fellows have become geothermal specialists in various aspects. A number of them are working at reservoir engineering, chemistry of geothermal fluid and geothermal utilization etc.

Ms. Lu Run, trained in 1982, is the first UNU-GTP fellow from Tianjin, and then three colleagues joined the training in 1985. They brought back many new concepts and technologies from the training courses, and shared their knowledge and experience with their colleagues. The Wanglanzhuang geothermal field is the first one explored and developed in Tianjin. The first exploration well drilled into basement rock was finished in 1979. Ms. Lu Run was the chief engineer of the exploration project of the geothermal field. She has now retired officially, but is still a consultant of TGEDI, and is also

giving computer courses to senior people in her community. Her life after retirement is also happy and splendid. The second geothermal field in Tianjin (Shanlingzi Geothermal field) was explored under the guidance of Ms. Chen Zhenxia. She made the best use of the knowledge learned from UNU-GTP and greatly brought forward the reservoir engineering study of the geothermal field. Mr. Zhang Baiming was the director of TGEDI a few years ago, and made a lot of contributions to the geothermal utilization in Tianjin. Dr. Wang Kun, who works with the Geothermal Division of Tianjin Bureau of Land Resources and Real Estate Management, is in charge of the geothermal management in Tianjin, and she also achieved a lot in geothermal reinjection and numerical modelling in Tianjin. Mr. Chen Wanqing, the head of geothermal geological department in TGEDI, is involved in several geothermal exploration and development projects related to reservoir engineering, geochemistry, and environmental studies.

TABLE 3: The situation of UNU Fellows from Tianjin

Name	Year of training	Field of training	Work engaged in / Institution
Lu Run	1983	Res. Eng.	Retired officially, still working on geothermal
Li Zhi	1984	Utilization	Retired
Zhang Jinzhang	1984	Borehole Geology	Retired
Lu Zhenyuan	1985	Geophys. Explorat.	Retired
Qi Baoxiang	1985	Borehole Geology	Retired
Chen Zhenxia	1985	Borehole Geology	Retired
Chen Xinming	1987	Utilization	Retired
Bai Liping	1991	Utilization	Emigrated to Australia
Dai Chuanshan	1992	Res. Eng.	Geothermal / Tianjin University
Dong Zhilin	1993	Res. Eng.	Emigrated to New Zealand
Li Youji	1993	Utilization	Emigrated to New Zealand
Zhang Baiming	1994	Res. Eng.	Reservoir engineering /TBGMED
Wang Kun	1998	Res. Eng.	Reservoir engineering /TBLRREM
Chen Wanqing	2001	Environment	Reservoir engineering / TGEDI
Li Jun	2003	Res. Eng.	Reservoir engineering / TGEDI
Li Junfeng	2004	Environment	Reservoir engineering / TGEDI
Lei Haiyan	2004	Utilization	Geothermal / Tianjin University
Wang Liancheng	2005	Utilization	Geothermal / TGEDI
Sheng Zhongjie	2007	Environment	Geothermal / TGEDI
Cao Fenglan	2008	Utilization	Geothermal / TGEDI
Zhang Wei	2008	Utilization	Geothermal / Tianjin University

Most of the fellows used to work with TGEDI or are working with TGEDI. The major tasks achieved by TGEDI are geothermal resource exploration and evaluation of new fields, such as the coastal region (including Tanggu, Hangu and Dagang), Wuqing county and deep basement reservoir in Tianjin urban area, etc. They have also drilled most of the geothermal wells in Tianjin and undertaken various jobs on geothermal utilization, such as space heating, swimming pools and agricultural use etc. TGEDI also fulfilled a lot of consulting services to many real estate projects related to geothermal development. All the achievements of TGEDI are closely related to the UNU-GTP fellows from Tianjin.

5. FELLOWS FROM OTHER PARTS OF CHINA

Apart from the fellows from Beijing and Tianjin, there have been 28 fellows from other part of the country participated the 6 month training in Iceland, including 2008. Most of them are playing important roles in geothermal exploration, research and development in the institutions they work with. The 4 fellows before 1982 have retired, 18 fellows are still working on geothermal, and 5 of them changed their professions. Owing to lack of complete information for all of the fellows, only a thjose who are well known in the geothermal community in China will be mentioned below.

TABLE 4: The situation of UNU Fellows from other parts of China

Name	Year of training	Place	Field of training	Work engaged in
Yao Zu-jin	1980	Hebei	Chemistry	Retired
Zhou Xi-xiang	1980	Sichuan	Borehole geophys.	Retired
Sun Kaiyao	1981	Hebei	Utilization	Retired
Shen Xing-wu	1981	Tibet	Utilization	Retired
Yu Heping	1987	Tibet	Utilization	Geothermal
Wang Li	1989	Hebei	Utilization	Non-geothermal
Wang Liangshu	1991	Jiangsu	Borehole geophys.	Non-Geothermal
Wang Guiling	1991	Hebei	Res. Eng.	Geothermal
Pingtsao Wangyal	1992	Tibet	Chemistry	Geothermal
Zheng Xilai	1993	Shaanxi	Chemistry	Non-Geothermal
Li Cheng	1994	Jiangsu	Res. Eng.	Non-Geothermal
Xu Shiguang	1995	Yunnan	Res. Eng.	Geothermal
Chen Zongyu	1995	Hebei	Chemistry	Non-Geothermal
Bi Erping	1997	Hebei	Chemistry	Geothermal
Du Shaoping	1997	Tibet	Chemistry	Geothermal
Sun Zhanxue	1998	Jiangxi	Chemistry	Geothermal
Du Jizhong	2000	Liaoning	Res. Eng.	Geothermal
Kang Fengxin	2000	Shandong	Res. Eng.	Geothermal
Huang Hefu	2000	Shandong	Drilling	Unclear
Li Hongying	2000	Hebei	Environment	Geothermal
Fan Liping	2000	Yunnan	Environment	Emigrated
Huang Maochang	2001	Hainan	Environment	Geothermal
Zhang Zhanshi	2001	Jiangxi	Chemistry	Geothermal
Fan Xiaoping	2002	Tibet	Res. Eng.	Geothermal
Yin Lihe	2002	Shaanxi	Res. Eng.	Geothermal
Hou Haiyan	2003	Henan	Environment	Geothermal
Luo Heng	2004	Guangdong	Environment	Geothermal
Chen Gongxin	2008	Jiangxi	Chemistry	Geothermal

Before his retirement, Mr. Yao Zu-jin, who used to work with the Hydrogeology and Engineering Geology Institute in Hebei, was one of the leading reservoir engineers in China, and his achievements are well recognized in China. Mr. Sun Zhanxue, the vice president and professor of the East China Institute of Technology that is in Jiangxi Province, is very active in geothermal research and education. Mr. Xu Shiguang, the chief engineer of the Yunnan Institute of Geological Exploration, is involved in a lot of the geothermal projects in Yunnan Province, such as the one in the famous Tengchong geothermal field. Mr. Kang Fengxin is the leading geothermal experts in Shandong Province. Ms. Li Hongying is a key person in Hebei Province for her great efforts in promoting geothermal utilization, such as the construction of the “no smoke city” by geothermal district heating in Xiongqian County. The 5 fellows from Tibet are all working on geothermal and are playing important roles in the geothermal development in Tibet.

6. THE WORKSHOP ORGANIZED BY UNU-GTP IN TIANJIN

The first UNU-GTP workshop in Asia “Workshop for Decision Makers on Direct Heating Use of Geothermal Resources in Asia” was held in Tianjin May 11-18, 2008. High ranking decision makers from China as well as other Asian countries with geothermal heating possibilities were invited. In all, 16 former UNU fellows from China and a few from other countries participated in the workshop. There were about 50 lectures from Iceland, China, Japan, Germany, Poland and Switzerland and the other Asian countries on the workshop, including 15 lectures by 6 UNU-GTP teachers and 18 lectures by former UNU Fellows from China and other countries.

This workshop is the first step for UNU-GTP to expand its capacity building activities by workshops or short courses on geothermal development in Asia. It will be followed by annual courses in China in specific aspects of direct utilization of geothermal resources, such as space heating, bathing and other purposes. The training needs are considered to be at two levels: a) Training of professionals with university degrees; and b) training of technicians and operators of district heating systems etc. It is expected that this courses will greatly help the geothermal utilization in China and other Asian countries.

7. CONCLUSIONS

Including 2008, 402 scientists and engineers, mostly from developing countries that have significant geothermal potential, have now completed the 6-month geothermal training courses, and 15 former UNU Fellows have completed a MSc degree in Iceland on a fellowship from UNU-GTP, by July 2008. In 1980, the first group of Chinese participated in the training programme. Since then, 70 Chinese fellows, from 15 cities, provinces and autonomous regions, have completed the six-month specialized geothermal training in Iceland, and one has completed an MSc degree. The Chinese fellows are playing a very important role in the geothermal development in the country, and many of the former UNU fellows have become leading experts in their specialties in deferent part of the country and several have become well known in the international geothermal community. The UNU-GTP has been supporting China's geothermal development greatly in the past 30 years. On the other hand, the geothermal training programme promoted the cooperation and friendship between China and Iceland significantly. It is recommended that the UNU-GTP will continue to accept fellows from China.

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