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ROLE OF CHINESE UNIVERSITIES AND RESEARCH INSTITUTIONS IN CAPACITY BUILDING

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ABSTRACT

This paper discusses the role of Chinese universities and research institutions in geothermal capacity-building based on the brief introduction of the China higher education system and the national innovation system today. The universities and research institutions have played a very important role in capacity building in the geothermal community through advanced geothermal talents training, short-term geothermal training for specific professional needs, scientific research, technology development and transfer, and as well as popularization of geothermal sciences for the past decades. The future activities on capacity building have also been discussed, such as establishment of an improved Chinese network of geothermal researchers and a web-based virtual geothermal university, and set-up of some training centres, as well as development of a national GIS database of geothermal scientific results.

1. INTRODUCTION

Economic development is increasingly linked to a nation's ability to acquire and apply technical and socio-economic knowledge, and the process of globalization is accelerating this trend. Comparative advantages come less and less from abundant natural resources or cheaper labour, and more and more from technical innovations and the competitive use of knowledge. Today, economic growth is as much a process of knowledge accumulation as of capital accumulation. It is estimated, for instance, that firms devote one-third of their investment to knowledge-based intangibles such as training, research and development, patents, licensing, design and marketing (Salmi, 2005). This is also true in the geothermal industry. Drastic progress in geothermal direct utilization for the past decade, for example, mainly comes from the application of advanced geothermal (ground-source) heat pumps technology.

The development and utilization of geothermal energy are associated with many scientific and technical aspects such as geology, geochemistry, geophysics, drilling techniques, geothermal reservoir engineering, chemical engineering, heating and cooling technology, power generation, agriculture and aquaculture, as well as health care and medical science and so on. For this reason, to make reasonable use of geothermal energy is really a challenging but important task.

For the past almost four decades, China has successfully built up its geothermal industry through Chinese geothermal scientists and technicians' hard working, and technical support from some developed countries such as Iceland, Italy, Japan and New Zealand. Now China already ranks number

one in terms of total amount of heat used for geothermal direct use in the world. However, in terms of technology,, China is still not among the most advanced countries for geothermal development, utilization and management. To some extent, irrational use of geothermal resource, environmental pollution, low efficiency, short equipment life-span, bad management, and unreasonable design still exists for some geothermal development projects in the country. In order to ensure the sustainable development of geothermal resource in china, capacity building for geothermal communities is of significant importance.

Capacity building can be defined as a dedication to the strengthening of economies, governments, institutions and individuals through education, training, mentoring, and the infusion of resources (Jones, 2005). For organizations, capacity building may relate to almost any aspect of their work: improved governance, leadership, mission and strategy, administration (including human resources, financial management, and legal matters), program development and implementation, fundraising and income generation, diversity, partnerships and collaboration, evaluation, advocacy and policy change, marketing, planning, etc. For individuals, capacity building may be associated with leadership development, advocacy skills, technical skills, organizing skills, and other areas of personal and professional development. As far as geothermal concerned, emphasis should be put on improving geothermal organizations' abilities to achieve their missions of geothermal development and utilisation or geothermal people's abilities to do their job more effectively, and particularly on raising the motivation and inspiration of people to use geothermal energy to improve their lives.

The examples of the United States of America, Germany and other developed countries reveal the critical role that universities, research centres, industries, foundations and government play in the institutionalisation of capacity building (Oni, 2000). The role of international organizations in capacity building in developing countries cannot be underestimated. The great contribution of United Nations University-Geothermal Training Programme (UNU-GTP) in Iceland to assisting developing countries and Central and Eastern European countries with significant geothermal potential to build up groups of specialists that cover most aspects of geothermal exploration and sustainable development is a typical example. Since the foundation of the UNU-GTP, 380 scientists and engineers from 41 countries (including 65 fellows from China) have completed the annual six month specialized courses offered (Ingvar, 2007). Most trained graduates are among the leading specialists in geothermal research and development in their own countries. However, in order to meet the need of the dramatically increasing geothermal market in China, high-level professional manpower and advanced technology should be mainly provided by home universities and research institutions. In this paper, the role of Chinese universities and research institutions in geothermal capacity building is focused on.

2. ROLE OF UNIVERSITIES

2.1 The Chinese University System Today

All over the world investment in university education is a critical component of national development effort. Nations today depend increasingly on knowledge, ideas and skills which are produced in universities (World Bank, 1997). Since the implementation of China's reform and opening up policy in 1978, China's higher education has made significant achievements. The role of universities in knowledge creation (basic and applied scientific research), knowledge diffusion (training science and technology talents) and knowledge application (service to economic development) has been paid more and more attention to for the past 30 years in China.

Higher education in China includes regular universities and colleges, advanced vocational institutions, and adult universities and colleges as well. Two- and three-year colleges which are also referred to as short-cycle colleges, typically awarding associate degrees, exist next to typical four-year colleges and universities which offer academic as well as vocational courses leading to bachelor degrees or higher.

Master's degrees and PhDs are offered by universities and research institutions which are accredited by the State Council (MOE, 2005). During the past five years from 2003 to 2007, the total number of new entrant admitted by the regular higher education institutions (adult universities and colleges not included) has increased from 3.82 million to 5.66 million (Figure 1). In addition, universities and research institutions enrolled a large number of postgraduates. For instance, 420,000 postgraduates were enrolled in 2007 (NBSC, 2008).

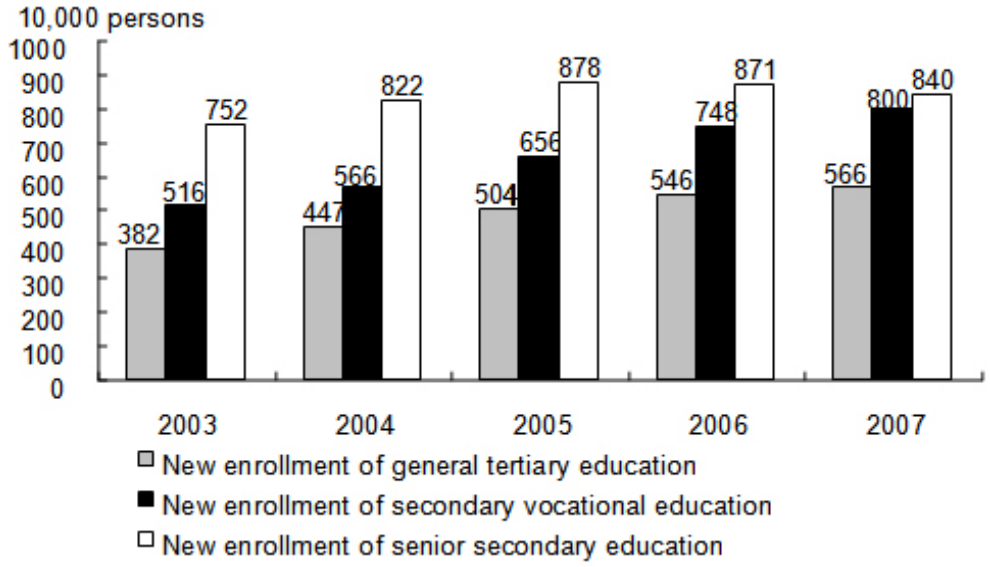

Figure 1: New Entrants into Education, 2003 – 2007 (Source: NBSC, 2008)

In recent years, taking advantage of their talents, knowledge, science and technology, the Higher education institutions (HEIs) emphasized the practical research and development in the light of economic construction of China and made a great effort to serve the central task of economic construction while at the same time strengthening the basic research. In addition, HEIs have taken part in the construction of science parks, established high-tech enterprises and combined industry, teaching and research together to turn the scientific and research fruits into real productivity and to spread them to the whole society. Higher education in China has been making a greater and greater contribution to the economic construction, science progress and social development by bringing up a large scale of advanced talents and experts for the country.

2.2 Role of Universities in Geothermal Capacity Building

Geothermal capacity building at universities has mainly been in the areas of advanced geothermal talents training, short-term geothermal training and popularization of geothermal sciences, but also in research, development and transfer of advanced geothermal technology.

2.2.1 Advanced geothermal talents training

There are around 50 universities with earth sciences in China (Bi & Hu, 2004). Most geothermal technical staffs in the country, engaged in geophysical and geochemical exploration, drilling technology, borehole geology, environmental studies, graduated from these universities. Most of them received a Bachelor, Master or PhD degree in the above-mentioned branches of earth sciences. Here taking the East China Institute of Technology (ECIT) as an example.

Formerly known as East China Institute of Geology, ECIT was founded in 1956. Today, ECIT is a comprehensive university with 23 departments, 1,600 professors, associate professors and instructors, and more than 26,000 students. The Institute offers 55 undergraduate and 30 graduate programs in the following fields: Geology, Geophysics, Geochemistry, Hydrology and Water Resource, Surveying, Civil Engineering, Applied Chemistry, Chemical Engineering, Nuclear Engineering and Techniques, Material Science, Environmental Science, Computer Science, Software Engineering, Electronic Engineering, Life Science, Economics, Business Management, Law, Chinese and Foreign Languages Study, Arts, Mathematics, Physics, etc. Almost every year, some of the graduates from the institute found their jobs in the geothermal market.

Although specific geothermal topics such as reservoir engineering and geothermal utilization are usually not presented in the existing under-graduate courses in the universities of the country, post-graduate specialisation in geothermal, is available in a few universities and training centres. For instance, the Geothermal Training Centre in Tianjing University offers Master and PhD Programs in thermoenergy engineering, heat pump technology, renewable energy, green building and new energy etc., and ECIT has post-graduate programs in geothermal geochemistry, geothermal geophysics and isotopic techniques in geothermal studies.

In some top universities and research institutions of the country, there are professional development schemes for postdoctoral fellow, research associates and visiting scientists to develop and share expertise in geothermal.

2.2.2 Short-term Geothermal Training

It is very important for geothermal workers to update their knowledge and skills on a regular basis because of the short "shelf life" of knowledge. The short-term geothermal training courses have been operated from time to time in some universities to meet the growing need of geothermal education in some specific areas. For instance, in collaboration with the International Atomic Energy Agency, ECIT has hosted several international training courses such as "Regional Training Course on Advanced Applications of Isotope Techniques to Development of Geothermal resources, Lushan, China, 4-18 June in 1996" and "Regional Training Course on Regional Hydrology Database for Surface Thermal Manifestations, Fuzhou, China, 1-12 June in 1998". Around 40 people participated in the two training courses from Burma, China, India, Indonesia, Pakistan, Thailand, Vietnam and some other Asian countries. For the past decade, ECIT has also conducted some local geothermal training courses as "Training Course on Development and Management of Hot Springs in Jiangxi Province, Fuzhou, 20-26 July in 2004" supported by Jiangxi Provincial Government.

2.2.3 Popularization of Geothermal Sciences

Geothermal capacity building can not work without supporting from the public, governmental agencies and enterprises. The universities should take the responsibilities to educate the people to pay more attention to using geothermal energy to improve their lives. The popularization of geothermal sciences can be very useful for us to inspire young people to embrace careers in geothermal development and utilization, to promote the value and advantage of geothermal energy use, and to raise the interests of the politicians, decision-makers and entrepreneurs in geothermal energy.

Popularization of geothermal sciences can be conducted through scientific popular books, audio and video materials, lectures and seminars, museums, television programs, web sites and so on. For the past decades, some influential popular geothermal scientific books (e.g. Liao, 1990; Wang & An, 1993; Wang & Sun, 2001) have been published in China. Some geothermal-related television programs have been also available in CCTV Science Channel and some Provincial TV stations. The authors or contributors of these geothermal popular scientific materials mainly come from universities. The

dissemination of general geothermal knowledge conducted by university teachers has been playing a more and more important role in promoting the sustainable use of geothermal energy in the country.

2.2.4 Research, Development and Transfer of Technology

University-based scientific research and technology development has been increasingly supported by government and enterprises for the past two decades in China. Geothermal research activities, both basic and applied researches, cover a broad spectrum related to the disciplines developed at the relevant universities. For various universities, they may focus on various geothermal research aspects. For instance, researchers in the Department of Geological Sciences, Peking University, have made great achievements on geothermal resources in the Yunnan-Tibet Geothermal Belt (Zhao & Liao, 1999; Dong et al., 2000), researchers in Tianjin University have done a lot of work on geothermal utilization (e.g., Cai, 2004; Zhu et al., 2006), and teachers in ECIT have conducted researches on geothermal resources in SE-China, and geochemical and isotopic techniques in geothermal studies (Zhou et al., 1998; Li et al., 2000).

Generally speaking, capacity building in geothermal can be strengthened by universities, collaborated with some research institutions and enterprises, through basic research which can provide basis for more applied geothermal technologies, and through developing new technologies, commercializing the developed technologies, and choosing, absorbing, using and improving the technology transferred from some developed countries.

3. ROLE OF RESEARCH INSTITUTIONS

3.1 China National Innovation System

With the increasing development of the world economy, science and technology, the Chinese government duly worked out important strategic decisions on constructing the National Innovation System. In 1998, it approved the Chinese Academy of Sciences (CAS) to initiate the Pilot Project of Knowledge Innovation Program (KIP). Soon after, an action plan was carried out for rejuvenating education in the 21st century, in addition, a national meeting on technology innovation and a working conference on basic science research were held in order to further enhance the reform of the scientific research system. Science and technology in China are moving forward at an unprecedented tempo in the new era (CAS, 2003).

China's National Innovation System is a networking system composed of institutions involved in knowledge innovation and technology innovation. It includes a knowledge innovation system netted with the state research institutions and key universities, technology innovation and technology application system with industrial enterprises, and knowledge dissemination system with schools and universities conferring different levels of degrees and with a lifelong education program open to the public. In this connection, the national institutes play a unique role in the popularization of science among the people for S&T development and expansion, and in the promotion of scientific methodology.

Since the implementation of KIP and the reform of the public research institutions in late 1990's, scientific research and technology development have been mainly made by three kinds of research institutions in China: the first is about 80 national institutes belong to CAS, the second is the universities, and the third is the enterprise-run institutes mostly transformed from former ministerial ones (Lan, 2007).

3.2 The Role of Research Institutions in Geothermal Capacity Building

The role of research institutions in geothermal capacity building is similar to that of universities discussed above. However, the research institutions more focus on scientific research, technology development and transfer, and higher degree training for leadership in scientific research.

3.2.1 Scientific Research, Technology Development and Transfer

In respect of basic science, the top research institutes in China are targeted to conduct cutting-edge research in some important and strategic areas, and to achieve creative scientific results with international significance, so as to enhance the overall research level of basic science in China, and remarkably enlarge the proportion of China's contribution to the science development of the modern world. For instance, the Institute of Geology and Geophysics, CAS (IGG-CAS) , has carried out a lot of research work on terrestrial heat flow of the whole country (Wang, 1996). The basic research can provide the basis for the studies of lithosphere thermal structure, tectonics, climatic change, the assessment of geothermal potential, and oil and natural gas exploration, as well as some other applications. The IGG-CAS has also conducted geoscientific investigations on typical geothermal systems in continental China, including North China Basin (Chen et al., 1989), Southeast China (Zhangzhou geothermal system in particular, Wang et al., 1993) and partly involved in Southwest China (Tibet and Yunnan Province in particular). These and other research projects have considerably improved the knowledge base for geothermal development in China.

In respect of high technology development, the research institutions have achieved outstanding results in new energy sources including geothermal energy. The output as the high-temperature drilling equipment, new-type ground source head pumps, innovative geothermal evaluation techniques, and high-efficiency heat exchanger can promote geothermal industrial development in China and make breakthroughs in research work with independently owned intellectual property rights.

In respect of technology transfer, the technical capabilities of geothermal enterprises can be improved by research institutions through the commercial application in industry of technology developed. For the past two decades, the gap which exists between the knowledge generators (in particular, universities and research institutions) and the market has been narrowed with the introduction of favourable governmental policies which support the collaboration among universities, research institutions and enterprises.

3.2.2 Higher Degree Training

In China, most research institutions of CAS offer Master and/or Doctor Degree Programs. After more than half a century of major development, CAS has formulated its unique interdependent and interactive graduate education mode of teaching and scientific research; hence, the establishment of the Graduate University of CAS (GUCAS) , the first graduate school in China, which is characterized by the broadest scope and the strongest overall capabilities. GUCAS, with its research and educational institutes distributed all over the country, has the best ensemble of professors with more than 300 members of the Chinese Academy of Sciences and/or the Chinese Academy of Engineering. GUCAS endeavours to make a prominent contribution to the economic development and social progress in China.

As to geothermal higher degree talent training, the IGG-CAS has played a major role. For the past two decades, about 100 post-graduates with Master or Doctor Degree in theoretical geothermics or applied geothermics from the institute have been active in geothermal enterprises, oil companies, universities, research institutions and governmental agencies all over China. Some other research institutions as the

Guangzhou Institute of Energy Conversion, CAS, also have Master or Doctorate Degree Programs in geothermal energy from time to time depending on funding availabilities related to geothermal studies.

4. DISCUSSION

The role of universities and research institutions in capacity building in geothermal fields can not be underestimated. It has been in the areas of advanced geothermal talents training, short-term geothermal training for specific professional needs, scientific research, technology development and transfer, and as well as popularization of geothermal sciences and so on. These capacity building activities have promoted the rapid progress of geothermal industry in China over the past decades.

Facing the challenge of globalization and distribution of knowledge in the modern world, the future activities of capacity building in geothermal should be considered in China:

Establish an improved Chinese network of researchers working on geothermal energy and relevant fields, and initiate closer collaboration. The Geological Society of China and the China Energy Association may assist to build the network using their extensive networks of geoscientists, geothermists, administrators and entrepreneurs.

Set up a web-based virtual geothermal university in China through the collaboration among universities, research institutions and enterprises. One or two key universities or research institutes may coordinate the program and to develop the online geothermal curricula under the close cooperation of involved institutions.

Found some training centres by local organizations collaborated with some international organizations such as UNU-GTP and IGA. As speculated by Fridleifsson (2005), longer term goals of the United Nations University and the UNU-GTP are to assist in the establishment of formal training centres with former UNU Fellows as main teachers in e.g. China, El Salvador, Kenya, and Philippines.

Develop a national GIS database of geothermal scientific results. A lot of geothermal energy research has already been done at China National Geological Survey, universities and research institutes, oil companies, etc. The available results and techniques should be inventoried, collected and subsequently harmonized. The data base should be made available as an on-going product, able to be updated with new work. The work should be coordinated by a governmental agency.

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