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STATUS AND PROSPECTS OF DEVELOPMENT AND UTILIZATION OF GEOTHERMAL RESOURCES IN CHINA

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ABSTRACT

It has made considerable progress in decade on the development and utilization of geothermal resources, including geothermal power generation of high temperature geothermal resources and direct uses of intermediate-low temperature geothermal resources, in China mainland. There are 1620 localities of geothermal uses equivalent to 5 million tons standard coals nationwide. The geothermal utilization entered the markets and has a certain competitiveness.

By geological survey, there are about 255 high-temperature geothermal areas, which appear suitable for purpose of electricity generation, with potentials of 5800 MW for 30 years in Chinese mainland. The projects of high temperature geothermal electricity generation will concentrate in southern Tibet and western Yunnan. The major projects are the exploitation of deep reservoir in the Yangbajain field and operation of the future geothermal power station in the Rehai field in Tengchong County of Yunnan Province. The intermediate-low temperature geothermal resources are widespread and large potential countrywide. The major projects are co-utilization of low temperature brine in high-latitude region and take geothermal heating as dominant field. The further works in exploitation of geothermal resources include: 1) research on reservoir engineering and geothermal environment effect to raise the utilization ratio of thermal energy and to improve eclogical environment; 2) research on geopressured geothermal resources; 3) progressive establishment and amplification of technological standard and rules of operation for geothermal exploration and exploitation to probel the geothermal industrialization; 4) developing of geothermal tourist and balneological network.

In past decades, the great advances in geothermal development and technology have been made by National Science and Technology Development Plan of eighth five year plan. These achievements can be concluded as follows.

1. ESTABLISHMENT OF GEOTHERMAL INDUSTRIALIZATION

1.1 It sets up a systematic and standard exploration working procedure for high-temperature geothermal resources, which stresses rational use of ripe geological theories and valid technological method and emphasizes to use new technology of geophysical and geochemical prospects and remote sensing to reduce risk, to shorten the period of exploration, to raise the percentage of hits of drilling and realize returns on an investment.

At same times, the geothermal resource assessment in Yunnan-Tibetan geothermal belt(YTGB)has been conducted . There are about 255 high-temperature hydrothermal systems with reservoir temperature above 150°C in YTGB. The total identified thermal energy in 255 hydrothermal convection system was calculated to be 267 EJ and the electricity producible from this resource to be 5800 Mwe for 30 years. Both the Yangbajain field of Tibet and the Rehai(Hot Sea)field of Yunnan are the largest projects for electricity production. Their capacity for each unit should be exceed 10 MW.

1.2 In order to raise the effect of exploration and exploitation in deep hole with high temperature, directional drilling and blowout prevention technology in high temperature geothermal well have been studied. The aims of research are to raise the percentage of hitting bull's-eye of drilling in complex layers and/or fracture belt and/or precipitous reservoir. Owing to high temperature, large flow rates, low drilling platform, short casings, portable drilling rig , as well as hard and tattered formation in geothermal field, a set of light unit with blowout prevent and killing well technology have been designed for safe operation of geothermal drilling.

Two prescriptions of drilling mud suitable for temperature up to about 250°C and a prescription of cement suitable high temperature have been made up. Their qualities come up to advanced world standard. Brief measuring apparatus and its operating sequence and cement mixing device have been offered.

Reinjection testing was carried out in the Yangbajain. The disposal water is injected into shallow reservoir. A study of the effect of inject ion was taken Waste hot water from power station is injected into upper reservoir to control heat pollution and to protect reservoir.

1.3 Two demonstration Counties for geothermal direct utilization, Xiongxian County in Hebei Province and Rucheng County in Hunan Province, have been built to study the scientific management method for raising efficiency of energy use and for reducing temperature of waste water.

Downhole heat-exchanger and assemble demonstration heating project have been developed. When well with 80°C at 100 m depth has fan out capability of 200 kW, the room temperature will keep to 18°C.

A sealed heating project has built at the Xiaotangshan of Beijing. The total area of project is 5000 m^2. The wellhead assembly kept free of any contact with the atmosphere.

A geothermal greenhouse was built at Nagqu town of northern Tibet with an elevation of 4500 m using the waste water from geothermal power station. The output of fresh vegetables is as higher as 6000kg/*mu*(a *mu* = 0.0667 hectares). It is first time to produce fresh vegetable on northern Tibet Plateau.

1.4 The elementary research in geothermics gain valuable progress. The mathematic modeling of balance for mass and energy of both the Yangbajain field and the Yangyi field have been developed to put forward exploitation plan and to forecast the change of reservoir parameters and its life-span.

At sometimes, using distribution parameter model, the development management model of the Zhangzhou geothermal field of Fujian Province has been developed to put forward production plan and to predict kinetic trend for 2010 AD.

The reservoir model of the Tanggu field of Tianjin has also developed. Complete automatic measuring equipment has been installed to obtain exact parameter and to predict the exploitation effects.

1.5 〝 Heat flow distribution of Chinese mainland and natural heat flow of thermal springs of China〞 with scale of 1:6000000 has been compiled. The potential of geothermal resources in China has been predicted.

Due to exploration of offshore petroleum, A typical example of geopressured zone is the Yinggehai basin of southwestern Hainandao Province. Geopressured reservoir exist in the depth range of 5 km and contain substantial amounts of natural gas as well.

2. THE IMPORTANT BREAKTHROUGH OF EXPLOITATION HIGH-TEMPERATURE GEOTHERMAL RESOURCES.

The Yangbajain geothermal power station is the biggest wei steam project in China. Its first 1 MW unit put into operation in 1977. Up to 1991, there were 9 units with installed capacity of 25.18 Mwe using 160-172°C flow from depth of 150 to 200 m at the Yangbajain station, which have provided 50% of electricity for Lhasa. The well ZK4002 is the deepest one drilled in the northern part of the field with a depth of 2006.8 m, and quite high temperature of 329.8°C were encountered at 1850 m depth. Another well(ZK4001)was subsequently drilled near ZK4002 to a depth of 1459.09 m with maximum temperature of 257°C. Its wellhead temperature is 200°C at pressure of 147N/cm^2. The total flow is 302 t/h and the amount of steam is 37.1 t/h from this well. The potential for electric generation from ZK4001 could be 12.58MWe.

The Yangyi geothermal field is another project able to produce electric power. Its feasibility report has been reviewed by experts. Upon receiving approval from the government, construction work will commence immediately.

The Rehai, including the Reshuitang , field of Tengchong County of Yunnan Province is another high-temperature hydrothermal system with reservoir temperature of about 250°C by geothermometers. Based on the results obtained from investigations from 1973, the first exploratory well was begun at western Reshuitang region in 1998 and is still drilling.

3. PROMOTING GEOTHERMAL HEATING, SAVING CONVENTIOAL ENERGY RESOURCES AND PROTECTING ECOLOGICAL ENVIRONMENT.

That State Economic and Trade Committee presided over 'The national technological interchange meeting for geothermal heating and saving energy resources' took place in Tianjin on December 1997. The presider and participants consider it necessary to speed up development of geothermal resources, to put geothermal resources to rational use, and to win still greater economic, social and environmental benefit. For this purpose, it should attach great importance to following problems:

3.1 It is necessary to build good scientific program, to avoid blindly mining, and to build scientific and rational using plan and implementing plan step by step, based on potential of resources and economic development.

3.2 It is necessary to advocate rational development, comprehensive utilization, to raise benefit, and to point out necessary adherent principle for geothermal utilization: using, protecting and saving.

3.3 It is necessary to make full use of the latest achievements in science and technology, to concentrate on demonstration work, to propel industrialization of geothermal utilization and to spread advanced new technology, and new materials

3.4 It is necessary to strengthen management, including management of resources, design of exploitation, engineering design, construction and operation, to make and amend necessary rules and regulations, to build monitoring systems for production and reinjection of geothermal field.

Our national 'ninth five-year plan' and long-range planning outline for 2010AD regard development of new and renewable energy as an important component of basic strategy of sustainable development. According to general objective and basic task of 〝 Developing outline of new and renewable energy of China from 1996 to 2010〞 ,it is necessary further to raise transform efficiency of heat energy, to reduce production costs, and to increase ratio of geothermal in energy composition in the next 15 years.

In recent years, current direct heat application have doubled and redoubled. According toimcomplete statistics, there are 1620 sites for geothermal development and use up to June 1998. Five geothermal power stations have total capacities of 29.166MWe. The production of electric energy of the Yangbajain project 10^8 kWh each year, which provide 50 per cent of the total electric energy of Lhasa network. Current direct heat utilization includes public bathing and swimming pool of 1245, balneological use of 420(mostly in Liaoning Province of 124), heating of greenhouse 0.69 million m^2(mostly in Hebei Province of 0.47million m^2),fishing pool of 2.97 million m^2 in 199 sites(predominantly in Guangdong Province of 0.79 million m^2 and Fujian Province of 0.55 million m^2), space heating 5.674 million m^2(3.05 million m^2 in Tianjin). Other uses include agricultural irrigation of 112 sites(50 sites in Yunnan Province), industrial use of 51 sites and 35 seismic observation stations. Moreover, there are 56 thermal springs tourist base, mostly in Hainan and Yunnan. The total thermal equivalent of these uses is estimated at 5 million tons of standard coal. The heat quantity in geothermal utilization increased at a rate of 12 per cent a year. The level of utilization escalate and has a competitiveness in market economic.

4. PROSPECTS IN THE FUTURE

4.1 There are huge potentials for geothermal development in Yunnan - Tibetan geothermal belt(YTGB), where there are 255 high-temperature hydrothermal systems, of which more than 10 geothermal field can be exploited from 1990s to 2010AD. At presently, it is necessary to develop high-temperature geothermals of Tibet positively and safely. The Yangbajain geothermal power station using 150°C thermal water from shallow reservoir are being perfected. At sometimes, the deeper reservoir with 250°C of the Yangbajain field and the Yangyi field will develop and use as soon as possible to form useful successive resources.

To the high-temperature geothermal resource in recent volcanic region of Tengchong region of western Yunnan, we must develop reservoir model conforming reality and select drill site for exploration and exploitation. The available

geothermal fluid in exceed of 250°C is expected for construction of geothermal demonstration power station with capacity of 10 MW each unit.

4.2 The geothermal exploration in high-latitute region will actively carry out for geothermal co-utilization taking heating as the dominant application.. As we know, the Song-Liao plain not only is rich in oil and gas but also is rich in geothermal energy. Based on recent regional survey and assessment of geothermal resources, there are multi-ply reservoir with temperature of 70-90°C beneath 1000-3000 m depth of the Song-Liao basin. The Song-Liao basin can match northern China plain in geothermal potentials. The area of individal thermal anomaly can go beyond 1000km^2. There could be the largest conductive geothermal field. The mean annual temperature is less than 4°C, the average minimum temperature in January is -20 - -22°C, the average maximum temperature in July is 20-22°C and the frost-free period is less than 150 days a year. There are a favorable climatic condition for geothermal heating. It is expected that Daqing oil field is able to become a demonstration base of geothermal heating in high latitude region of our country.

4.3 It is necessary to develop reservoir engineering and environment engineering for raising efficiency of heat energy use and eclonogic environment benefit. It is necessary to build production-reinjection system for developed field and different reinjectin system for different reservoir.

4.4 It is another task to unfold the study of exploitation and utilization of geopressured geothermal resources and to accumulate a wealth of data for exploitation of geopressured resources.

4.5 It takes further step to establish and perfect technological standard and necessary rules and regulations for exploration , exploitation and utilization of geothermal resources, to push geothermal extensive development forward intensive and to promote geothermal industrialization.

4.6 It is possible to take a comprehensive assessment of thermal and mineral waters once again and to set up a new domain for tourism, recovery and convalescence.

I brief, geothermal development and application will push extensive forward intensive, will go up a new level and ought to make a greater contribution to social and economic development of our country.

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