Proceedings World Geothermal Congress 2015
Melbourne, Australia, 19-25 April 2015

A New Round of Survey and Assessment of Geothermal Resources in China

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Keywords: geothermal resources, survey, assessment, China

ABSTRACT

Along with the transfer from planning economy to marketing economy in China, the national input for geothermal resources exploration reduced a lot. Geothermal resources have great potential for confronting the necessity of change for energy structure in China. But it is rather obvious that we have not sufficient available base for geothermal development requirement. Even though the Yangyi geothermal field had completed exploration before, but it still met various difficulties during the process of geothermal power plant construction. It shows the urgency for a new round of geothermal survey and assessment in the country. Ministry of Land and Resources has started to implement the plan for new round of survey and assessment of geothermal resources. It will be completed within 5 years from 2012. The primary mission is: 1) survey and measurement for hot springs and geothermal wells, and then for the resources assessment; 2) exploration demonstration for high temperature geothermal anomaly area; 3) development demonstration for selected medium-low temperature geothermal fields; 4) economic and social benefit evaluation and ecological environmental impact; 5) shallow geothermal energy survey and evaluation. It could be expected that the new achievement would serve for the demands of accelerating geothermal development in time. The paragraphs should not have line breaks between them – the Normal style will space the paragraphs automatically.

1. INTRODUCTION

China is located on the Circum-Pacific geothermal zone and the Himalayan geothermal zone, so there are plenty of geothermal resources in China. According to the geologic structure, transmission mode of geothermal fluids, temperature and utilization ways, geothermal resources of China can be classified to three types: shallow geothermal resource, geothermal resource of hydrothermal type, and geothermal resource of hot dry rock type.

1.1 Geothermal Resource of Hydrothermal Type

Geothermal resource of hydrothermal type of China can further divided into two types: conductive type of sedimentary basin and convective type of mountain uplift.

1.1.1 Convective Type of Mountain Uplift

Most of this geothermal resources type has a banding distribution, and hot springs expose to the earth surface. Based on the outcrops of hot springs, there are four hydrothermal geothermal zones: the South Tibet-West Sichuan-West Yunnan hydrothermal active area, the Taiwan hydrothermal active area, the Southeast Coastal hydrothermal active area, and the Jiaodong Peninsula and Liaodong Peninsula hydrothermal active area. High temperature geothermal resources distribute mostly on the South Tibet-West Sichuan-West Yunnan and Taiwan hydrothermal active area, while medium-low temperature resources distribute on other zones. The existing thermal springs, hot springs, boiling springs, fumaroles, are totally more than 3,150. Geothermal recoverable resources of the convective type of mountain uplift reaches up to 6.6×10^{17} J/a estimated up-to-date, equivalent to 22.59 million t/yr of standard coal.

1.1.2 Convective Type of Sedimentary Basin

There are 392 basins with a total area more than 4 million km^2, relatively rich in conductive geothermal resources. Most of them have band distributions within regional areas. But differences between east and west China are obvious. In the east, geothermal resources of the conductive type are mostly located on Songliao Basin, North China Basin and Subei Basin. In middle west, they are mostly located on Jiang-Han Basin, Fen-Wei Basin, Erdos Basin and Sichuan Basin. In the basins, reservoir systems of multi-layer overlapping are developing well. The main geothermal reserviors are the Mesozoic and Cenozoic sandstone pore type reservoir and Paleozoic and Middle Upper Proterozoic carbonate karst fractured reservoir. Heat flow values in the basin are much higher, and natural gas is included in geothermal fluids of geopressure type. Geothermal recoverable resources of the conductive type of sedimentary basin reaches up to 2.496×10^{22} J estimated up-to-date, equivalent to 853 billion tons of standard coal .

1.2 Shallow Geothermal Energy

Specification for shallow geothermal energy investigation and evaluation DZ/T 0225-2009 was issued in 2009 in China. In this standard, shallow geothermal energy is defined as: Heat energies are stored in rock and soil, groundwater some depth below the earth and surface water, having values of development and utilization. Further noted as: Heat energies can be obtained by ground source heat pump (GSHP) within 200m below the surface and the temperature below 25°C. Such low grade thermal energy stored in the stratum downward extending from the subsurface constant temperature zone is formed by the heat conduction from deep earth, so we named it “shallow geothermal energy”. It is used for heating, cooling and hot water supply by heat exchange technologies of heat pump currently.

Shallow geothermal energy is distributed widely in China with a large development potential. According to statistics, application areas using shallow geothermal energies are up to 210 million m^2 by the end of 2012. The amount of heat obtained from shallow

geothermal energies is equivalent to that of 8.4 million tons of standard coal, accounting for 0.26% of the current total energy consumption amount in China (3.25 billion tons of standard coal).

1.3 Geothermal Resource of Hot Dry Rocks Type

China is located on the strong tectonic activity areas distributed along boundaries between the Indian Plates and the Eurasian Plates, and between the Eurasian Plates and the Philippines Plates respectively. There are necessary condition and heat background for strong hydrothermal activities and warm water heat systems. At the areas of South of Tibet, West of Yunnan, North of Hainan, Changbai Mountain and Wudalianchi, volcanic rocks distribute widely with records of modern volcano eruption in recent 200 years. Background of geological structure in this area explains that regional tectonic condition for producing geothermal resource of hot dry rocks type existed in China. If you use equations, define all symbols, either after the equation, or in a Nomenclature section at the end of the paper.

2. RESERVED RESOURCES IS THE BASIS OF DEVELOPMENT STRATEGY

Geothermal energy is a new clean and renewable energy sources and environmental friendly. It has large reserves with a wide distribution, so its developing prospects are broad and the market potential is large. There are important actual meanings and long strategy meanings of development and utilization of geothermal energy, which include easing the pressure of energies and resources, realizing the goal of non-fossil energy, pushing the revolution in energy production and consumption, and promoting the construction of ecological civilization.

Geothermal development and utilization has a history of over 2000 years in China. During 1950s, investigation for hot springs has been launched and distribution map of hot springs had been drawn up. From the beginning of 1970s, reconnaissance and exploration of geothermal resources was launched in more than 20 provinces successively. Till to 1980s, 103 geothermal fields have been explored. Since 1990s, exploration and development of geothermal resources mainly depended on market demand, and the enterprises were the main body pushing on this work. Since 1999, China Geological Survey launched exploration of geothermal resources in Yinchuan Plain of Ningxia Province, Beijing, Guanzhong Basin of Shaanxi Province, and North Shandong Province successively. Ministry of Land and Resources organized national geothermal resource potential assessments and planning demonstration in succession.

But on the whole, exploration precision of geothermal resources in China is low and the total amount of resources is not clear. Comprehensive exploration and evaluation of geothermal resources have not been carried out in most areas. Geothermal fields with proven reserves are only 1/3 of all the fields discovered. Exploration and evaluation lags behind the development and utilization. Basic geothermal geological exploration work is weak, reserving resource is lack, and the conflict between supply and demand of geothermal exploration is prominent.

Large scale development and utilization of geothermal resources is the inevitable requirement for the development of Chinese society and economy. So, increasing the intensity of geothermal resources exploration and evaluation, finding out resources amounts, further exploring the geothermal field, delimiting developable and usable areas, then providing resource bases are all the emergency tasks for the implementation of the development and utilization strategy of geothermal resources of China. It is also an important basic work.

3. NEW ROUND OF SURVEY AND ASSESSMENT OF GEOTHERMAL RESOURCES

In order to enlarge the development and utilization of geothermal resources, China government has put renewable energy including geothermal energy into the priority areas of national energy development, and drafted the medium and long term development planning. Ministry of Land and Resources organized a new round of survey and assessment of geothermal resources in 2012, aimed to provide scientific basis for geothermal exploitation, also to provide important basis and technical support for management of geothermal resources by government departments at all levels.

3.1 Main Goals and Mission

3.1.1 Work Goals

Based on the full use of the existing achievements, the government first need to find out the current situation of development and utilization of the geothermal resources, delimit resource potential areas, evaluate the total amount of geothermal resources and the usable amount of potential resources; To carry out pilot exploration of the typical high temperature geothermal anomaly area, environmental benefit assessment of typical geothermal development regions , research on technology for geothermal resources survey and evaluation. It can provide scientific basis for the rational development and utilization of geothermal resources and the implementation of energy conservation and emissions reduction strategy.

Other goals includes evaluation of shallow geothermal energy of major cities, exploration of major geothermal fields, completion with the zoning and evaluation of geothermal resources, last establishment of national geothermal resources database and management system.

3.1.2 Major Mission

(1) National survey of geothermal resources status. Survey the existing springs and geothermal wells and detect water chemistry, assess geothermal amount, put forward suggestions for sustainable development and protection division.

(2) Evaluation of shallow geothermal energy of major cities. Carry out survey on shallow geothermal energy in proper cities, find out the distribution and occurrence conditions, evaluate energy amount of development potential, and draw up development and utilization planning of shallow geothermal energy.

(3) Exploration of typical geothermal fields. Carry out further exploration in prospective areas; find out the distribution of geothermal resources of typical geothermal fields and the burial patterns of geothermal reservoirs. Find out physical field, pressure

field, geothermal fluid chemical field of each reservoir, also forming conditions of geothermal fluids, then establish reservoir model, evaluate the total amount, exploitable volume and exploration potential.

(4) Ecological environmental impact evaluation. Ten representative areas may be chosen to evaluate their ecological environmental impacts. Dynamic monitoring will be set up for typical geothermal wells. Economic, social and ecological environmental benefit evaluation will be launched. Assessment report on environmental benefits is expected to submit.

(5) Comprehensive research. Establish production-study-research innovation system. Organize geothermal research center based on efficient research institutes, increasing the study on key technology of geothermal energy development. Encourage conditional enterprises to work on evaluation technologies, geothermal power generation, reinjection of tail water, water treatment and mineral extraction and so on. Speed up the industrialization process of key technology for geothermal use.

3.2 Implementation Scheme of Projects

The new round of survey and assessment of geothermal resources is arranged by Ministry of Land and Resources, implemented by China Geological Survey, and undertaken by geological prospecting teams, colleges and universities, research institutes and other units.

(1) National survey of geothermal resources status is organized mainly by each province (region, city). Based on the means including survey of geothermal resources status of all the springs, geothermal wells and geothermal fields, data analysis, sample detect, in situ test, dynamic monitoring and so on, information of geothermal geological background, thermal physical parameters of rocks , physical parameters of thermal water, chemical characteristics, dynamic change are obtained. Then on the basis of data analysis, assessment of regional geothermal resources potential and zoning of development an utilization are carried out, last national geothermal resources database and management system are established. Achievements expected to submit includes: evaluation and zoning reports of provinces (region, city) geothermal resources status, regional atlas of Chinese geothermal resource distribution and its exploitation and utilization (including national, provincial and regional geothermal geological map, geothermal resources distribution map, genetic types geothermal resources, zoning map development and utilization of geothermal resources).

(2) Evaluation of shallow geothermal energy of major cities will be carried out at 287 cities, mainly organized by each province (region, city), promoted by cooperation of province and Ministry of Land and Resources. First select the Tianjin city to carry out the pilot work, uniform the methods and techniques. Secondly, based on the experiences obtained from the pilot work in Tianjin, spread this work to the other provinces. Finally, carry out the investigation and evaluation for prefecture-level cities. Based on the identification of shallow geothermal energy storage, carry out zoning of development suitability, and draw up the development and utilization plan.

(3) Exploration demonstration of typical geothermal fields may be carried out at high and medium-low temperature geothermal anomaly areas. Exploration target area of high temperature geothermal mainly distribute along the Qinghai-Tibet Railway, South Tibet and South Sichuan; Exploration target area of medium-low temperature geothermal mainly distribute at the North China Plain, Huang-Huai Basin, Northern Jiangsu area, Hetao Plain, Jianghan Plain, Jiaodong, Liaodong, the southeast coastal area, north of the Tianshan Mountains and the Longdong depression. According to the principle of data collection, supplementary exploration work, find out the situation of geothermal resources, outline the geothermal anomaly zone, organize the comprehensive evaluation and development planning. Geothermal resources prospecting report is expected to submit.

(4) Ecological environmental impact evaluation. Ten representative areas may be chosen to evaluate their ecological environmental impacts. Dynamic monitoring will be set up for typical geothermal wells. Economic, social and ecological environmental benefit evaluation will be launched. Assessment report on environmental benefits is expected to submit.

(5) Comprehensive research. Establish production-study-research innovation system. Organize research center of geothermal based on efficient research institutes, increasing the study on key technology of geothermal energy development. Encourage conditional enterprises to work on evaluation technologies, geothermal power generation, reinjection of tail water, water treatment and mineral extraction and so on. Speed up the industrialization process of key technology for geothermal use.

3.3 Current Work in Progress

By the end of 2013, the survey work of development and utilization of the geothermal resources has be implemented, preliminary investigation delineated at Gulu and Yuzhai geothermal anomaly area along the Qinghai-Tibet railway, as the priority target region of high temperature geothermal power generation in the future. Shallow geothermal energy survey and evaluation has succeeded in Tianjin. Shallow geothermal resources investigation was also basically completed in provincial capitals. Heat exchange rate in every year is about 3.85 trillion kWh, equivalent to about 473 million tons of standard coal. If all could be developed and utilized, annual energy saving will be 1.92 trillion kWh, equivalent to 236 million tons of standard coal, and 818 million tons of carbon dioxide can be reduced. The exploitation of hot dry rock resources site was started, and the national terrestrial heat flow chart, acidic intrusion rock distribution map, Curie depth map and the inside heat control structure diagram was completed. The potential target of the hot dry rock was proposed.

3.4 Support Measures in National Level

The state will take three supportive policies to actively promote a new round of geothermal resources survey and evaluation and utilization. First is to strengthen the planning guide. The relevant departments of State Energy Administration, Ministry of Land and Resources, and Ministry of Housing and Urban-Rural Development carry out joint development of geothermal energy and overall planning, to guide the exploitation and utilization of geothermal resources, and promote the establishment of provincial geothermal energy development planning. Second is to improve the price and tax support policy. The central finance support geothermal resources exploration and evaluation, heating and cooling project, power generation and comprehensive utilization demonstration project. Also encourage the province (region, city) to introduce specific support policies combined with the actual

factors. Third is to establish the market mechanism. It should encourage the specialized service corporation to engage in the construction and operation of utilization of geothermal energy. Power grid enterprises fully purchase geothermal electricity, promote the use of geothermal power generation in accordance with national requirement for renewable energy power.

4. PROSPECTS OF GEOTHERMAL DEVELOPMENT IN CHINA

The Chinese government promulgated *the Renewable Energy Law of the People's Republic of China* in January 1, 2006, which gave priority areas of energy development in the non-fossil energies, such as wind energy, solar energy, hydro-energy, biomass energy, geothermal energy and ocean energy etc. It worked out the national mid- and long-term development plan for renewable energy in 2007, which planned and deployed geothermal energy as the key development areas. The target of geothermal energy development and utilization every year will reach 12 million tons of standard coal in 2020. However, in 2013 the target had been added up to 50 million tons of standard coal.

In the guidance of law and plan, we believe that the launching of a new round of geothermal resources survey and evaluation project will set off a new upsurge for the development and utilization of geothermal resources in China. With the improvement of exploration precision, Chinese geothermal resource potential will be expanded. With the breakthrough of technology, economic capability and the government's strong advance, Chinese exploitation and utilization of geothermal resources will increase rapidly.

Passing through preliminary estimation, in the amount of development and utilization of China hydrothermal type geothermal resources in 2020, the installed capacity for high-temperature geothermal power generation will reached 20×10^4 kW, low-temperature geothermal utilization could reach 17 GW, equivalent to 5.1 million tons of standard coal in total, accounting for 0.1% of China's total energy consumption by then.

By the end of 2012, the application areas using shallow geothermal energy for heating (or cooling) had reached 210 million m^2. The amount of heat obtained from shallow geothermal energy is equivalent to that of 8.4 million tons of standard coal, accounting for 0.26% of the current total energy consumption amount in China (3.25 billion tons of standard coal). At present its annual growth rate is more than 30%. It is expected that in 2020 shallow geothermal energy development and utilization in the 287 prefecture-level cities can be accounted for 1.9% of China's total energy consumption by then.

REFERENCES

The official website of the Ministry of Land and Resources on 22 April 2011: The press conference of working result of land and resources system on dealing with the global climate change, energy-saving and emission reduction (2011) . (in Chinese)

Wang G.l.: Major breakthroughs for assessment of geothermal resources potential in China, *Geothermal Energy*, 5, (2013),25-27. (in Chinese)

Wang G., Li K., Wen D., Lin W., Lin L., Liu Z., Zhang W., Ma F., Wang W.: 2013, Assessment of Geothermal Resources in China, *Proceedings,* 38th Workshop on Geothermal Reservoir Engineering, Sandford University, Stanford, CA (2013).