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Study on the Strategy of Development and Utilization of Geothermal Resources in China

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ABSTRACT

Even though the Chinese used energy for medium-low temperature geothermal direct utilization occupies the first place in the world, but the level for development showed large difference. In vast inland and jumping-off, it is lag in technology and serious wasting of resources. Facing the abundant high temperature geothermal resources in Southwest China and serious reality of power shortage in Tibet, but geothermal power generation grew rather slow. This paper introduced a consulting research project with the same topic name set up by Chinese Academy of Engineering. We will research on geothermal resources development and utilization status, geothermal resources long-range perspectives and industrial distribution, environmental problem and countermeasure, and key technology and relevant policy. Finally we will put forward the strategy of development and utilization of geothermal resources and road map in China.

1. INTRODUCTION

Energy is the cornerstone of a country's development. With the high pace of economy development in China, foreign trade and the trade surplus continue to expand. However, energy crisis has gradually become reef of China's long-term economy developing, and even has the trend of further deterioration. It is known that Chinese economic aggregate only accounts for 4% of the global and ranks seventh in the world, while the energy consumption has been ranked No.2 for a long time. As a resource-poor, large population and comprehensive manufacturing-dependent country, energy consumption is a heavy burden. The new energy development has been a priority to deal with the energy crisis.

Geothermal energy is a kind of valuable mineral resources and a new type of clean renewable energy from the earth. Although the total amount of direct use of low-medium temperature geothermal resources in China is the highest of the world, the development of utilization levels vary considerably across the country. In the vast inland and remote areas, there is serious waste of resources because of the backward technology and equipment. Nationally, comparing to the rich high-temperature geothermal resources and high demand of electricity in Tibet, geothermal power development is seriously falling behind. Therefore, it is important to start comprehensive exploitation strategies, make reasonable development and utilization plans, formulate effective protection measures and achieve sustainable development of China geothermal resources. These initiatives could accelerate the pace of geothermal resources survey and exploitation, and promote the balanced development of renewable energy in China. They have great significance of alleviating the energy crisis we are facing.

Geothermal resources have the highest capacity factor among all kinds of renewable energy. Geothermal power is not affected by the weather, so it is very stable. In light of the high thermal efficiency, geothermal power is suitable for building base load power grid, which could show significant advantages in the substitution of conventional fossil fuel energy. However, the development of geothermal power is very slow in recent 30 years. Because China's low temperature geothermal resource utilization ranks first in the world, and we used to be satisfied with this achievement and ignored the deficiencies we had. In fact, geothermal utilization level is deficient in many places of hinterland. Due to the lack of planning and management, geothermal resources wasted seriously. Since there were no geothermal reinjection measures generally, geothermal power resulted in environmental pollution in some place. In order to accelerate the development of geothermal resources, promote energy-saving and emission reduction, improve the energy structure and prevent haze, we need to carefully consider the strategy of geothermal resources development and utilization in China. That would make China geothermal industry adapt to the current and future development of the world.

This research is based on the advanced technology and development direction of international geothermal resources survey and utilization. By making full use of the related results on geothermal resources evaluation and exploitation, combining with the potential and utilization conditions of geothermal resources at present, aiming at the main problems in the development and utilization of geothermal resources in our country, we analyze geothermal resource potential and development prospects of China, especially thermal power generation potential and utilization prospect. In this study, we would find the problem, and put forward the policy government need to improve China geothermal resources development. Though adjusting the design concept and development strategy, China could accelerate the roadmap of geothermal resources development and protection.

2. CURRENT STUDY OF CHINA GEOTHERMAL RESOURCES DEVELOPMENT AND UTILIZATION

The highlight of the global geothermal resources development and utilization is geothermal power generation. In 1904, the first geothermal generated electricity was produced in Larderello, Italy. In 1913, the world's first commercial geothermal power plant started generating. It has been running for more than one hundred years so far. In 1950s-1960s, New Zealand, American, Japan and other countries had implemented the geothermal power generation successively. Till 1970-1980s, geothermal power generation had been implemented in more countries around the world. By the end of 20th century, geothermal power was still higher than wind power and solar power generation all over the world. Although the world wind power and solar power installed capacity is far higher than that of geothermal power generation in recent years, the wind power output just exceeded the geothermal power in 2010, while the solar power is still unable to compare with geothermal power. These facts fully show the advantages of geothermal power.

In 1970, China successfully tested geothermal power generating, and became the 8th country which could implement geothermal power plant. China also built 7 low-medium temperature testing geothermal power plants at the same time. However, those testing plants were all shut down after completion of research report. The conclusion was technically feasible, but economically unviable (the cost was too high). So Chinese stopped the research on the low-medium temperature geothermal power generation. Although the Tibet Yangbajain geothermal power plant was built in 1977, and it has been operated since then, geothermal power development is very slow and seriously behind world for decades.

Comparing with other countries, there is a huge conception difference between Chinese and Westerner. We stopped our steps, while they tried to lower the cost and improve the efficiency by continuous research of 30 years.

Although the total amount of direct use of low-medium temperature geothermal resources in China is the highest of the world, the development of utilization levels vary considerably across the country. In the vast inland and remote areas, there is serious waste of resources because of the backward technology and equipment. Nationally, comparing to the rich high-temperature geothermal resources and high demand of electricity in Tibet, geothermal power development is seriously falling behind. So we should formulate a comprehensive plan of geothermal power development and geothermal resources laddered utilization.

3. PERSPECTIVE ANALYSIS AND INDUSTRIAL LAYOUT RESEARCH OF GEOTHERMAL RESOURCES IN CHINA

Geothermal resources are divided as different types and grades. In general, high temperature geothermal resources apply to electricity generation, while low-medium temperature geothermal resource is suitable for direct heat use. In addition, enhanced geothermal systems (formerly known as hot dry rock) have become research upsurge of the world in recent years. This kind of resource is widely distributed and has greater potential.

High temperature geothermal resources in China are mainly distributed in the western Tibet to Yunnan Province, which belongs to the geothermal belt of eastern Mediterranean-Himalaya; other geothermal resources are distributed in Fujian and Guangdong, locating in southeastern coast of China, which are near Pacific geothermal belt. Tibet is suffering serious power shortage, conventional energy resources deficiency and ecological environment vulnerability. So Tibet is very suitable for the development of geothermal power, and should pay more attention to comprehensive laddered heat utilization.

China has huge amount of low-temperature geothermal resources. According to the recent evaluation survey, the quantity of geothermal resources in China is 18□106TJ. Most geothermal resources are suitable for direct use, but part of the medium temperature geothermal resources could be used for generating electricity. Especially in the oil region, there are more than ten thousands of abandoned wells, and almost 1/3 of the wells which have the temperature higher than 90°C could be used as first resources for power generation.

Unlike the high temperature geothermal resources, hot dry rock resource is not limited distributed, and often has high grade. So it can be used for power generation. The American latest research called hot dry rock resource as twenty-first Century energy, and thought it has the potential to be commercialized. France, Germany and Australia already have the successful megawatt class power tests. According to the preliminary hot dry rock resources assessment recently completed, in China, the quantity of recoverable resources within 3-8km underground is 12.6×10^4EJ. It is 1,320 times as much as the total energy consumption in 2010. As a big energy consuming country, China has already carried out researches on the key technology of hot dry rock energy development and comprehensive utilization so as to ensure energy security and reduce external dependence, and plans to begin hot dry rock drilling in 2014.

In order to have better direct utilization of low-medium temperature geothermal resources in our country, we need to consider using intensive technology of development and utilization on industrial layout to reduce energy waste, improving the efficiency of geothermal energy utilization to reduce costs, and enhancing the capacity of geothermal reinjection to guarantee the long-term sustainable development and resource protection.

4. ENVIRONMENT PROBLEM ANALYSIS AND COUNTERMEASURE RESEARCH IN THE PROCESS OF THE DEVELOPMENT AND UTILIZATION OF GEOTHERMAL RESOURCES IN OUR COUNTRY

Because there is no burning process during geothermal resources development and utilization, the traditional air pollution would not happen. However, geothermal water is rich in minerals and usually makes up mineral water. The positive aspect is its medical value, while the negative aspect is that if we could not take care of the waste hot water from geothermal power generation or heat utilization, it would lead to surface water, soil polluted by certain minerals such as fluorine, bromine, sulfur and other chemical pollution, or by the pollution of waste heat. This is one of environmental problems we should pay attention to.

Some geothermal water stores in shallow unconsolidated sediments. Long-term exploitation of this kind of shallow geothermal reservoir would cause ground subsidence. We should pay attention to this kind of environmental problems as well.

In addition, noise is produced in the process of high temperature geothermal using; hot dry rock fracturing can cause micro earthquake; high temperature geothermal fluid contains hydrogen sulfide, carbon dioxide and other gases. All these by-products might cause environmental problems.

Though geothermal resources could be referred as a kind of clean energy, it might produce pollution factor. Therefore, we should also strengthen the study of related aspects, foster strengths and circumvent weaknesses, and take appropriate countermeasures such as waste hot water reinjection to maximize benefits.

5. THE RESEARCH KEY TECHNOLOGY AND THE ROADMAP IN THE DEVELOPMENT AND UTILIZATION OF GEOTHERMAL RESOURCES IN OUR COUNTRY

In January 2013, "The guidance of promoting development and utilization of geothermal energy from the National Energy Administration, the Ministry of Finance, the Ministry of Land and Resources, the Ministry of Housing and Urban-rural Development" is issued to determine the "12th five-year" goal of geothermal development. The completion of the tasks and goals is a big challenge. How to complete the mission we are facing? On the basis of widely research above, we extract the key technology of the development and utilization of geothermal resources in China to breakthrough. We also need to adjust our strategy and steps, and draw a new map to adapt to geothermal development in our country, so that we could guide a balanced development of geothermal industry. The preliminary roadmap we considered is showed in table 1 and figure 1, which list the positive and feasible development indicators.

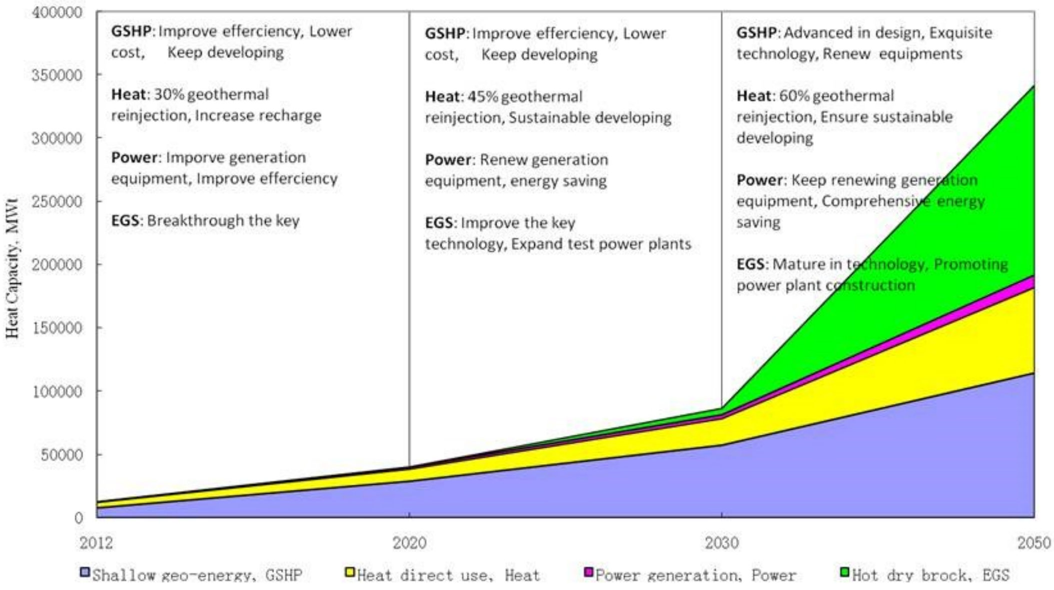

Figure 1: The Science Course of Geothermal energy development and utilization

6. RELATED POLICY RESEARCH ON THE DEVELOPMENT AND UTILIZATION OF GEOTHERMAL RESOURCES IN OUR COUNTRY

Including "the renewable energy law", many relevant preferential policies have been enacted for the surveys, development and utilization of geothermal energy domestically. In January 2013, the national energy administration published "the guidance on promoting the development and utilization of geothermal energy". In order to earnestly implement the programmatic document, we need some more detailed rules and specific policies for the implementation. Especially for major geothermal power projects, demonstration project should be set up as earlier as possible, so that more developers would be attracted and kept up with the developing steps. The development mechanism of keeping "blood making" rather than "blood transfusion" would further promote the healthy development of geothermal industry in China.

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Table 1: The science course of geothermal energy development and utilization

	2012	2020	2030	2050
GSHP (C.F.=0.20)	2.1×10^8 m^2 =7,500 MWt =47,304TJ =2.6880×10^6 tce	8×10^8 m^2 =28,560 MWt =180,132TJ =1.0235×10^7 tce	1.6×10^9 m^2 =57,120 MWt =360,265TJ =2.0470×10^7 tce	3.2×10^9 m^2 =114,240 MWt =720,530TJ =4.0939×10^7 tce
Geothermal Utilization (C.F.=0.36)	4,550 MWt Growth rate: 10% per year =51,656TJ =2.9350×10^6 tce	9,753 MWt Growth rate: 8% per year =110,725TJ =6.2910×10^6 tce	21,056 MWt Growth rate: 6% per year =239,046TJ =1.3582×10^7tce	67,529 MWt =766,649TJ =4.3560×10^7tce
Heat utilization instead of standard coal	5.6230×10^6tce	1.6526×10^7tce	3.4052×10^7tce	8.4499×10^7tce
Geothermal Power Generation (C.F.=0.70)	27.78MWe =277.8MWt =6,132TJ =3.480×10^5 tce	150MWe =1,500MWt =33,113TJ =1.881×10^6 tce	300MWe =3,000MWt =66,225TJ =3.763×10^6 tce	1,000MWe =10,000MWt =220,751TJ =1.2543×10^7 tce
Hot Dry Rock (C.F.=0.70)	0	1MWe =10MWt =221TJ =1.300×10^4 tce	500MWe =5000MWt =110,375TJ =6.271×10^6 tce	15,000MWe =150,000MWt =3,311,258TJ =8.814×10^7tce
Geothermal power generation		15.1MWt	80 MWt	1,600 MWt