Renewable and Sustainable Energy Reviews 32 (2014) 651–661

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Current situation and prospect of China's geothermal resources

Xin-gang Zhao *, Guan Wan

School of Economics and Management, North China Electric Power University, Beijing 102206, China

ARTICLE INFO

Article history:
Received 16 September 2013
Received in revised form
5 January 2014
Accepted 11 January 2014
Available online 6 February 2014

Keywords:
Geothermal energy
Renewable energy
Industrial policy

ABSTRACT

At present, countries around the world set off a round of upsurge of exploitation and utilization of geothermal energy. As one of renewable energy resources, geothermal energy has the advantages of great resource potential, low carbon emissions, widespread distribution, easy development and so on. China's geothermal resources are enormous and have huge potential for exploitation. However, due to the lack of reasonable industry planning and policies support, and lag of technologies, the industrial development speed and scale are far behind the wind, solar and biomass energy. The 12th Five-Year Plan for National Economic and Social Development of the People's Republic of China explicitly issues that in future China will vigorously develop the geothermal energy and provide more policy support for geothermal industry development from medium to longer term. This paper describes China's geothermal resource potential and status quo of geothermal industry, and analyzes the obstacles of the industry development. Then, it accordingly puts forward the development pattern of China's geothermal industry and gives out related countermeasures. At last, it outlines the prospects in this field.

Contents

* Corresponding author. Tel.: +86 10 51963571; Mobile: +86 130 4115 7885.
E-mail address: rainman319@sina.com (X.-g. Zhao).

1364-0321/$ - see front matter © 2014 Published by Elsevier Ltd.
http://dx.doi.org/10.1016/j.rser.2014.01.057

1. Introduction

With the rapid development of economy and the need of the energy conservation and emissions reduction in China, the existing energy structure is no longer rational. Renewable energy development and utilization are gradually paid attention to by the whole society. As a kind of pollution-free energy, geothermal energy plays an important role in alleviating the pressure of energy supply and improving the ecological environment, which gets the favor of the government and enterprises [1].

On August 6, 2012, National Energy Board released "the 12th Five-Year Plan". According to the plan, the total development and utilization capacity of geothermal sources should reach 15 Mt standard coal by 2015. Among them, geothermal power installed capacity would reach 100 MW, shallow geothermal heating and cooling building area would reach 5×10^8 m^2 [2]. What is more is that China's geothermal sources are abundant. According to official figures released by China's Ministry of Land and Resources (MLR) recently, the total Hot Dry Rock (HDR) resources distributed at depths 3–10 km are equivalent to 2,60,000 times the capacity of annual energy consumption of China in mainland China. That is to say, the geothermal resources in China are equivalent to 8.6×10^{14} t of standard coal, which can be used about 2,60,000 yr for national consumption.

In the aspects of the development potential of geothermal resources, Guiling Wang et al. [3] assessed and summed up the resource potential in shallow, sedimentary basins, apophysis mountains and hot dry rocks (HDR, potentially for enhanced geothermal systems, EGS) in China by using different methods and models. Guiling Wang [4] summarized the main problem of exploration and evaluation of China's current geothermal resources and put forward the main tasks and work in future. Jiyang et al. [5] updated the heat flow map in the continental area of China on the basis of more new heat flow data, and then estimated the geothermal resources in the continental area (3–10 km). Kewen et al. [6] investigated and modified the methods of estimating geothermal resources coexisted in oil and gas field.

In the fields of development and utilization of geothermal resources, Xia [7] and Yanxia [8] believed some problems existed in China's geothermal industry, which included the low level of exploration and evaluation, lag of technologies, lack of the geothermal resources information management system, and some countermeasures have been proposed. Jinhua et al. [9] pointed out that only exploited in rational way, can geothermal resources be considered a kind of renewable energy, therefore, the sustainable development of geothermal resources are very important. Guiying et al. [10] systematically reviewed status quo, problems of China's geothermal industry and made recommendations. Melih et al. [11] indicated that Turkey's geothermal power installed capacity was expected to reach 500 MW by the year of 2021 subsequent to the implementation of "Renovation of Standards and Regulations" and "Fiscal Approaches".

Up to now, papers about China's geothermal lack the new data and systematization. This paper supplemented the newest data and systematically introduced the resource potential, the status quo of development and utilization, policy situation and the obstacles of geothermal industry in China. Finally the cooperation mode of "government–enterprise–university–research institution and application" was applied to provide theoretical references for the development of geothermal energy in China.

2. Geothermal resource potential

China is a large country with rich geothermal resources, in which low-medium temperature type occupies a major position. China's geothermal resources potential is tremendous, close to 8% of the total around the world. From 2009 to 2011, the MLR reappraised shallow geothermal energy of more than 287 local cities, geothermal resources of 12 main sedimentary basins and 2562 apophysis mountains in hot spring area, as well as HDR resources at depths 3–10 km. So far, the work has made some progress as shown in Table 1. Table 1 indicates that China's geothermal energy is mainly distributed in the sedimentary basins and the HDR.

From the point of resources distribution, geothermal resources in China cover all over the country, but the distribution is not balanced (Fig. 1). The high temperature geothermal resources mainly scatter in Tibet, Yunnan and Taiwan region. The low-medium temperature geothermal resources mainly distribute in the southeast coastal area like Hainan, Guangxi, Guangdong, Jiangxi, Fujian, Zhejiang as well as cenozoic large and medium sedimentary basins such as Sichuan, north China, north Jiangsu, Erdos and Songliao.

From the perspective of resources exploration and evaluation, there are 103 geothermal fields in China having been formally prospected and approved by the competent department of territorial resources at present. More than 2000 geothermal wells have been dug and 214 geothermal fields have been preliminary evaluated. In addition, the submitted B+C grade exploitable geothermal resources have reached 330 million m^3/yr and the D+C grade exploitable geothermal resources have reached 500 million m^3/yr [13].

3. The status quo of China's geothermal industry development and policies

3.1. Current situation

In the early 1970s, the world was facing the first oil crisis, and countries all over the world generally attached the importance to the development of renewable energy. China is one of the earliest countries that used geothermal resources in the world. Since 1990s, China's geothermal development and utilization have been booming driven by market demand [14]. At present, China has initially formed integrated development and utilization system of geothermal resources. It centers on power generation and direct utilization which includes heating and cooling, spa treatment, agricultural use, industrial production, etc. In addition, since hardly restricted by resources distribution, the utilization of shallow geothermal energy in China has developed rapidly in recent years, and then the technologies also became more and more mature. China's direct-use capacity of low-medium temperature geothermal resources per year has consistently ranked first in the world over the past 20 yr. The rank of capacity used by ground source heat pumps (GHP) in a short span of 10 yr has jumped to the second in the world just after the United States [15].

Table 2 illustrates China's geothermal power generation, direct-use (except for GHP) as well as GHP utilization in 2009. As can be seen from Table 2, China's GHP utilization occupies a very large component of the total geothermal, and has a promising future.