



Review

A review of geothermal energy resources, development, and applications in China: Current status and prospects



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ABSTRACT

The objective of this paper is to introduce geothermal energy resources, utilization, development roadmap, and government support in China. Over the last 20 years, China was the first place in the world in direct utilization of geothermal energy with total amount reaching 17,870 MWt in 2014, and with an increasing trend annually. Compared with the rapid increase of direct utilization, the development of geothermal power generation in China is not obvious in the past 40 years, with an installed capacity of 27.78 MWe, ranking 18th in the world at present. It is reported that geothermal heating area was up to 396 million square meters with an installed capacity of 1178 MWt in 2013. Research on HDR (hot dry rock) resources is in its infancy. Considering the recoverable coefficient of 2%, energy stored in HDR at a depth of 3.0–10.0 km is 4500 times the total energy consumption in China in 2013. In order to achieve sustainable development of geothermal energy in China, attention should be paid to the following aspects in the future: technology development of EGS (enhanced geothermal system), low cost and scale-up of geothermal power generation, cascade utilization in geothermal heating, and sustainable exploitation and utilization of geothermal reservoirs.

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1. Introduction

The sustainable development is facing three critical problems: a rapidly growing world population, energy shortage, and ever-increasing environmental pollution. At present, many countries around the world are engaging in research on new energy, especially on renewable energy, in order to gradually reduce their nation's dependence on traditional fossil fuels [1–3]. It is reported that electricity generation from renewables is expected to triple between 2010 and 2035, reaching 31% of total generation [4]. The variations of total primary energy and renewable energy consumption are shown in Fig. 1 [5], which shows a noticeable increase in electricity generation from renewables since 2003.

The proportions of power generation from renewable to the total electricity generation using different energy sources and to the total power generation only using renewables are shown in Fig. 2 and Fig. 3, respectively [6]. Obviously, the power generated

from geothermal energy is just 0.3% of the total power generation and 1.5% of the power generated from renewables.

Compared with solar, wind and hydraulic energy [2], geothermal energy, as an abundant, no CO₂ emission, and stable natural resource, has attracted more attention [7]. The temperature in the Earth's interior exceeds 5800 °C [8], and the energy stored inside the earth is inexhaustible compared to the others [9].

There are roughly 82 countries (regions) making use of geothermal energy directly [10–12], and 26 countries (regions) using geothermal energy for power generation [13–17]. The geothermal applications worldwide are shown in Fig. 4 [5,15]. The top 10 countries in geothermal power generation and direct utilization are shown in Fig. 5 and Fig. 6, respectively [15,16]. United States is the lead country in geothermal applications with the largest installed capacity of geothermal power production, reaching 28.8% of the total installed capacity of the world. It also has the second largest installed capacity of geothermal direct utilization, reaching 24.6% of the total. Although China is number one in direct geothermal utilization, reaching 25.2% of the total, the installed capacity of geothermal power generation in China is only 27.78 MWe, accounting for 0.2% of the total and ranking 18th in the world.

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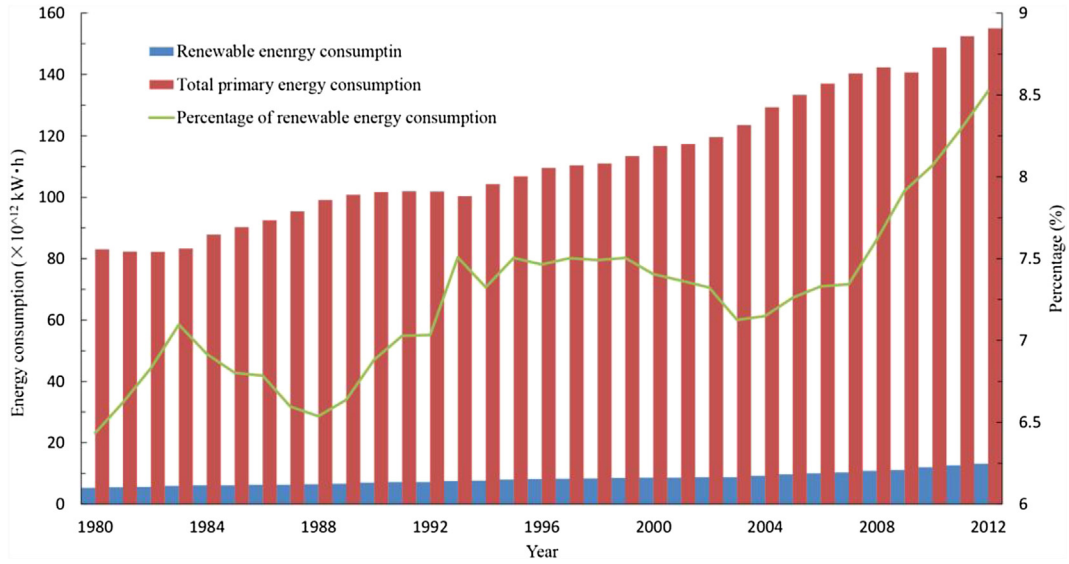


Fig. 1. Global total primary energy and renewable energy consumption [5].

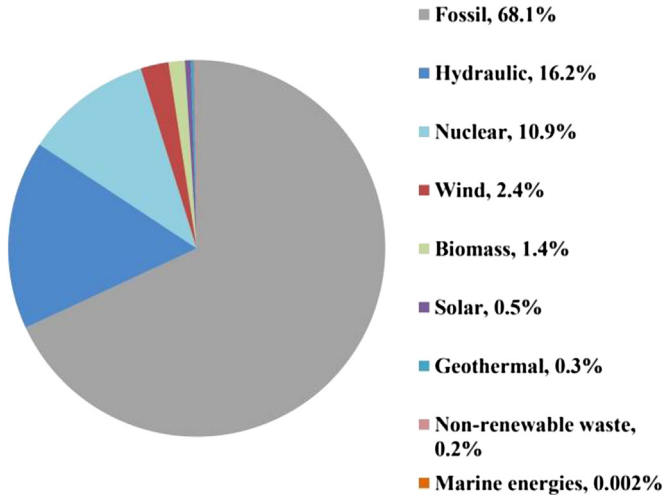


Fig. 2. Structure of the world's electricity production, 2012.

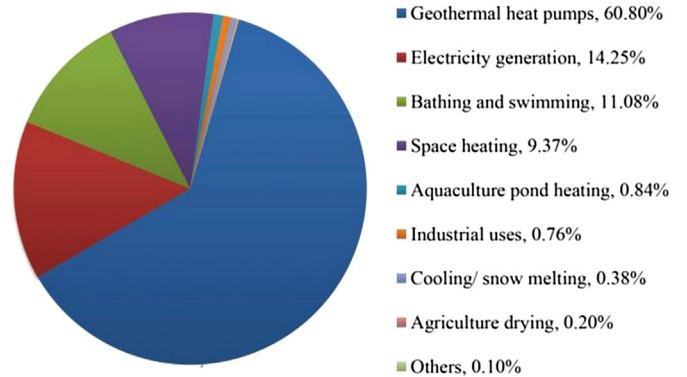


Fig. 4. Geothermal energy applications worldwide in 2014.

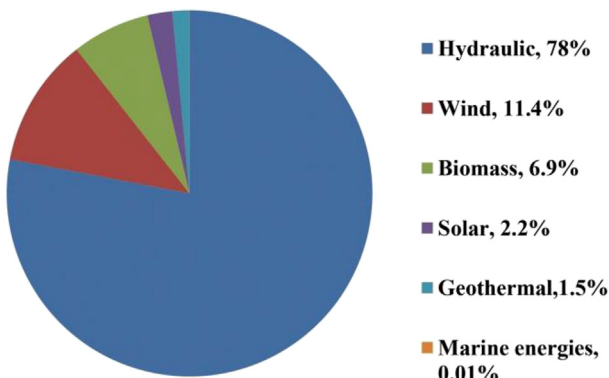


Fig. 3. Structure of the world's electricity production from renewable sources, 2012.

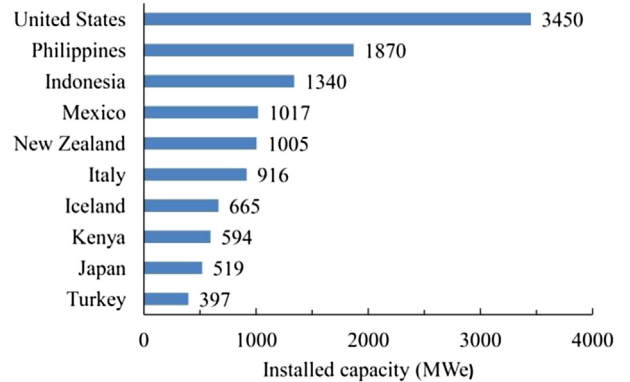


Fig. 5. Top 10 countries in geothermal power generation in the world.

Fig. 7 shows the growth of installed power generation worldwide [5,18]. The installed capacity of geothermal power generation boomed during the past few years, reaching 12,013 MWe in 2014. In Fig. 7, the “Global Installed Capacity” represents the total installed

capacity running at present, while the “PCA (planned capacity additions) of Plants Under Construction” includes the geothermal power plants under construction. Supposing all the geothermal power plants under construction will be put into operation as expected, the total installed capacity will be up to 13,452 MWe by 2017 [5,18].

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