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Review

Direct utilization status and power generation potential of low-medium temperature hydrothermal geothermal resources in Tianjin, China: A review

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ABSTRACT

The objective of this paper is to introduce the resource reserves, utilization status, power generation potentials, problems and outlooks of development of low-medium hydrothermal geothermal resource in China, especially in Tianjin. Tianjin is one of the earliest and biggest cities in China to utilize the geothermal resource, and the geothermal resource of Tianjin is featured as low-medium hydrothermal geothermal resources. Data of utilization of geothermal resource in Tianjin is taken in this paper by years from 2001 to 2014, and by utilization patterns which including space heating, domestic hot water, bathing and agriculture. A case study of the geothermal power generation in Tianjin is proposed and analyzed to reveal the feasibility of power generation by the methods of optimization and grey relational analysis. Besides, a 500 kW grade geothermal power plant will be built in Tianjin in 2016. At last, Outlooks are proposed to achieve the sustainable exploitation and development of low-medium temperature hydrothermal geothermal resource in the view of underground and above-ground, such as strengthening the injection, monitoring, and exploitation of geothermal resources; enhancing hydrothermal geothermal power generation and absorption refrigeration technologies, and exploring the potential applications of multiple energy system based on the principle of temperature matching.

Contents

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Nomenclature

ORC	Organic Rankine Cycle
Flash	flash cycle
Kalina	Kalina cycle
ARS	absorption refrigeration system
Nm	Minghuazhen group
Ng	Guantao group
Ed	Paleogene formation dongying group
O	Paleozoic ordovician group
∈	Cambrian group
Jxw	Mesoproterozoic jixian wumishan group
GRA	grey relational analysis
HE	heat exchange equipment
T	temperature, °C
P	electric power, kW
Q	thermal power, kW
W	work, kJ/kg
E	exergy, kJ/kg
h	specific enthalpy, kJ/kg
s	specific entropy, kJ/kg K
m	mass flow rate, kg/s
η	efficiency, %
C	cost, 10^4 ¥
X	the ratio of power used for the operation of the plant, %

Subscripts

in	at the inlet
out	at the outlet
ex	heat exchanger
eva	evaporator
pre	preheater
th	thermal
ex	exergy
op	the optimal state
max	maximum

1. Introduction

Geothermal energy is one of the most promising renewable energy resources due to its high availability (Nasruddin et al., 2016), ranging from shallow ground to hot dry rock as well as molten rock, which is known as magma, in the earth's core. It has been proven that geothermal resources are more than sufficient to meet the energy needs of humans. Furthermore, another important feature of geothermal energy is that it is cleaner than traditional fossil fuel (Boyd and Lund, 2015).

Geothermal resources have been extensively distributed in China in diverse categories. The use of geothermal resources has been developed for several centuries in China. A few studies investigated the utilization of geothermal resources in China, including the following reviews.

Zhu and Hu (2015) reported the scale of geothermal energy resources, utilization and government support in the whole China, and revealed that technology of low cost and scale-up of geothermal power generation, cascade utilization in geothermal heating etc. should be adopted in future in order to achieve sustainable development of geothermal resource in China; Zhao et al. (2014) described the potential of the development of geothermal resource and status of geothermal industry, and analyzed the obstacles of the development of geothermal industry of China. In addition, the authors put forward the development patterns of geothermal industry and offered some proposals for the problems; Feng et al., (2014) focused on the capacity of enhanced geothermal system in China and introduced the relevant technologies of development. In the meantime, the authors revealed that a coming work aiming at heat flow survey in deep layer should be adopted due to the geothermal measuring wells in China are too shallow and too few to offer an accurate estimation.

Eager concerns have been focused on the rapid development of geothermal use in China. It should be noted that Tianjin was one of the earliest cities in China to develop and utilize geothermal resources, and the scale of direct use of the geothermal resource has been continuously ranking first in China in recent years. However, thus far, the literature on the geothermal use in Tianjin and China lack data, especially with respect to the utilization of low-medium temperature hydrothermal geothermal resources. In fact, geothermal resources in Tianjin are featured as typical low-medium hydrothermal geothermal resource, which is extensively distributed in China. Therefore, the objective of this paper is to introduce the resource reserves, utilization status, power generation potentials, problems and outlooks of the development of a low-medium temperature hydrothermal geothermal resource in China, particularly in Tianjin.

The four primary sections of this paper are introduced as follows:

1. Status of the geothermal utilization in China is introduced with geographical information;
2. Data of the geothermal utilization in Tianjin are introduced based on years and patterns;
3. A geothermal power plant is proposed and analyzed to be built in Tianjin;
4. Underground and above-ground countermeasures are proposed to achieve the sustainable exploitation and development of the geothermal resources.

2. Reservoirs and utilization status of low-medium temperature hydrothermal geothermal resources in China

Geothermal energy in China is abundant and produces a value of 3.06×10^{18} kWh/yr, thus occupying 7.90% of the total global geothermal energy reserve (Zhu, 2015). As depicted in Fig. 1, geothermal resources are spread all over China. Furthermore, it can be easily seen that the terrestrial heat flow pattern in China is high in the southwestern regions and low-medium in the eastern and northern regions. Particularly, the low-medium geothermal resource is primarily located in sedimentary basins, such as the Sichuan basin and the North China plain. The geothermal resource