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Trends in patents for solar thermal utilization in China

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ABSTRACT

Since 2000, solar thermal utilization (STU) has a great process in China, not only with a large scale commercial development, but also with an increasing number of scientific publications and patent applications. In this paper, several representative technologies of STU in China are studied based on an analysis of the relationship between patents and policies. Patent information of STU is collected and analyzed in terms of the time distribution, type distribution and technical trends. The main driving factor—energy policy—was discussed through the patent analysis. STU patents took off after the millennium and 85.8% of them came from the solar water heater. For conventional technologies, 94.2% of the granted patents were from companies and individuals, and the patents proposed by various research institutions were mainly in the technological beginning and technological maturity. Advanced technologies are still at a growth stage in China, and they have 412 patents in all and 70.5% of the patents were from systematic design and test method. Energy policies have played a significant role in promoting the progress of STU in China. Based on a patent analysis, it can be expected that STU will enter the age of medium-high temperature in China.

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1. Introduction

Because of an increasing pressure on energy demand, global warming and environmental protection, the entire human society has been searching for a secure and sustainable development solution in the energy supply. Researches and demonstrations on renewable energy utilization (REU) became active since the last decades. Particularly, a great number of new technologies on REU were successfully used in commercial applications under the patent protection.

Renewable energy includes solar energy, wind energy, hydraulic energy, bio-energy, geothermal energy, marine energy, etc. It contains huge value of potential utilization and less environmental pollution for a sustainable development. Since the 1970s, the sustainable development has become a consensus of international society, especially in the field of REU [1]. Many countries adopted REU as an important part of the energy strategy, announced a series of specific development goals or roadmaps, and published laws and policies to promote the development of REU.

Solar energy, which is an ideal renewable energy, has many advantages, such as no pollution, a huge total radiant power and an endless supply in human history. The development of STU has already become an essential measure for the sustainable development of the human society. STU has a long history for various simple applications, such as drying with sunlight. The direct method of STU is converting solar radiation to thermal by conversion materials. At present, solar water heater (SWH), solar cooker and solar passive house are widely adopted, especially in the developing states. For instance, many researches about solar water heater, solar space heating and solar cooker are very popular in Turkey [2–4]. Whereas some advanced technologies, including solar thermal power system, solar photovoltaic (PV), solar cooling system, and solar desalination, are still at the stage of experimentation and investigation.

China embraces sufficient solar energy, which is widely used in many fields. The nationwide issue of smog and haze in China highlights the urgency to upgrade heating systems in northern China to systems that require less coal and reduce pollutant emission [5]. In order to obtain a leading advantage in the future energy market, a number of groups and firms actively have already experienced a “land grab” in solar patenting under the support of policies. Therefore the patent analysis or reviews, which involves statistical, analytical, and comparative methods for examining information in patent documents, have been conducted in many research fields recently, such as the fields of CO_2 capture technology [6] and organic Rankine cycle [7]. However, the number of patent reviews on solar thermal technologies was few, even fewer for solar technologies in China. Nick et al. [8] analyzed patent data from 25 countries over the period 1978–2003 and concluded that public policy played a significant role in determining patent applications for renewable energy. In Refs. [9–11], the trends in patent applications for solar cells were researched. Frauke et al. [12] studied the development of global concentrating solar power technologies by a patent data. Wang [13] analyzed the strategic thought for Chinese solar enterprises and proposed a patent development strategy that the solar energy industry can be improved by building up patent network and patent pool. Arnaud et al. [14] analyzed the success and the limits of the Chinese photovoltaic industry by a review of international patent data, with a particular emphasis on the role of technical transformation and innovation. Literature research implied that there were no published studies of the trends in patents for STU in China. In this article, we have collected patents and established a database, which has 7373 patents about STU in China. The database is used to analyze time distribution, type distribution and technical trends based on a literature research. Moreover, driving factors to patent applications are discussed as well, such as the influence of policies and the update of technologies. Through classification and analysis, some conclusions about trends in patent applications are drawn and the potential development directions for STU in China are predicted.

This study is organized as follows. We begin with a general introduction of solar energy resources in China in Section 2. Section 3 describes the patent dataset and research method for STU technologies. Then we present our analysis of patents for conventional STU technologies in Section 4 and advanced STU technologies in Section 5. Subsequently, we will discuss possible development directions for STU in the future. Finally the conclusions and recommendations are given in Section 7.

2. Solar energy resources in China

China is a large country with a land area of about 9.6 million km^2, and it belongs to those so-called Sun Belt countries [15]. Figs. 1 and 2 show the Chinese map of solar direct radiation [16] and

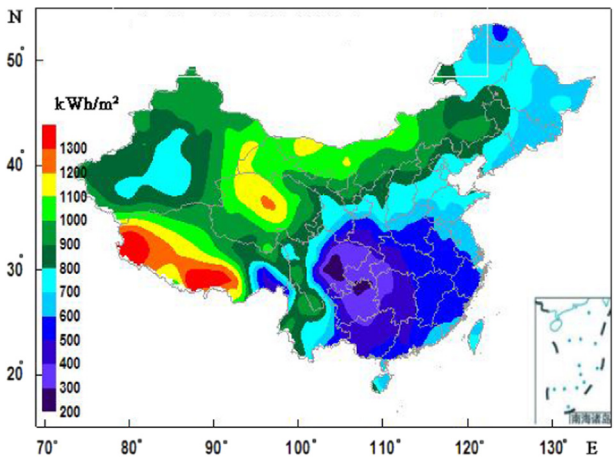

Fig. 1. The distribution of mean annual total solar direct radiation in China, 1978–2007.

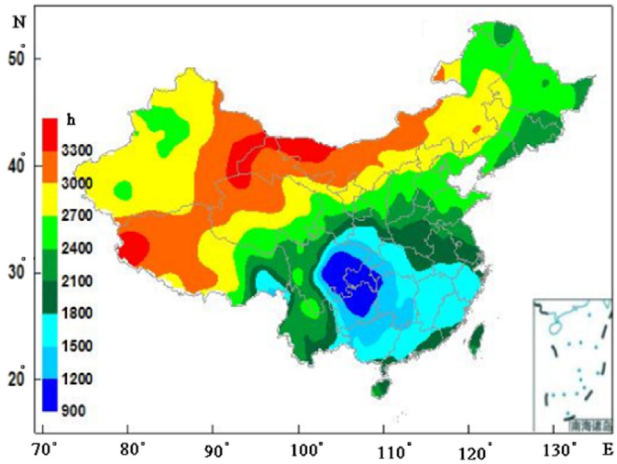

Fig. 2. The distribution of mean annual total sunshine duration in China, 1978–2007.