Renewable and Sustainable Energy Reviews 58 (2016) 966–975

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

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

Chinese energy and fuels research priorities and trend: A bibliometric analysis

Hua-Qi Chen [a,*], Xiuping Wang [a], Li He [b], Ping Chen [c], Yuehua Wan [d], Lingyun Yang [a], Shuian Jiang [e]

[a] Library, Taizhou University, No. 605, Dongfang Avene, Linhai 317000 Zhejiang, P. R. China
[b] Library, Zhejiang Normal University, No. 688, Yingbin Road, Jinhua 321004, Zhejiang, P. R. China
[c] Department of Chemistry, Xixi Campus, Zhejiang University, No. 148, Tianmushan Road, Hangzhou 310028, Zhejiang, P. R. China
[d] Library, Zhejiang University of Technology, No. 18, Chaowang Road, Hangzhou 310014, Zhejiang, P. R. China
[e] School of Economy and Trade Management, Taizhou University, No. 1139, Shifu Road, Taizhou 318000, Zhejiang, P. R. China

ARTICLE INFO

Article history:
Received 28 May 2014
Received in revised form
22 November 2015
Accepted 24 December 2015

Keywords:
Energy & fuels
Bibliometric
Bubble chart
Keyword analysis
Science Citation Index Expanded

ABSTRACT

This study aims to summarize an overview of Chinese energy and fuels research using comprehensive bibliometric analysis measures based on data extracted from the Science Citation Index Expanded database from 1993 to 2012. Keyword analysis was used to assess and evaluate the priorities, topics and topic shifts using the Thomson Data Analyzer (TDA). In particular, popular topics were demonstrated using bubble charts. The results show that solid oxide fuel cell (SOFC), lithium-ion batteries and hydrogen were the most important topics. The priorities of energy and fuels research in China were hydrogen and fuel cells, lithium-ion batteries, biodiesel and biomass, coal, and solar energy, respectively. Of course, lithium-ion batteries have entered substantive application stages in China in 2012. The hydrogen economy has been formed. Biomass and biodiesel research was the popular topic, as well as hydrogen and fuel cells, lithium-ion batteries. But solar energy was not still "hot". The characteristics of the types of documents, languages, year, journals, institutions and co-publishing countries were analyzed, as well as the keyword occurrence frequencies. It can be stated that 19,089 articles by Chinese authors were published in 106 journals. More than one-third of the articles were published in the *Journal of Power Sources*, the *International Journal of Hydrogen Energy* and *Bioresource Technology*. The Chinese Academy of Science, Tsinghua University, China University of Petroleum, Shanghai Jiao Tong University, and Zhejiang University were the top five institutions. The USA was the leading inter-collaborative country, followed by Japan, the UK and Canada. The findings presented here provide an overall picture of the development of Chinese energy and fuels research and could also help policy makers assess the impact of the resource allocation decisions made in the past to develop energy policies and strategies for the future.

Contents

* Corresponding author. Tel.: +86 576 85137262; fax: +86 576 85137039.
E-mail address: crhq2001@126.com (H.-Q. Chen).

http://dx.doi.org/10.1016/j.rser.2015.12.239
1364-0321/

1. Introduction

Neither China nor the rest of the whole world can live without energy. In 2011, China's energy production ranked first in the world, reaching 3.18 billion tons of standard coal. Chinese energy self-sufficiency has always remained nearly 90 percent [1]. Energy consumption accounted for 3.48 billion tons of standard coal, 68.4 percent of the total consumption and exceeded two times than the amount in 2002 [2]. The energy supply system, which has excessively relied on coal, has resulted in environmental problems such as haze and high carbon emission. However, China's energy needs will continue to expand due to its rapid economic development. As a result, China has two problems: energy conservation and emission reduction and national energy supply security [3]. Therefore, it was noted in the 12th Five-Year Plan for Energy Development that successful resolutions of the two problems, i.e., energy supply security and environmental pollution, are necessary for the basic realization of modernization by the middle of this century. The Journal Citation Reports' (JCR, 2012) category description of energy and fuels comprises all types of nonrenewable fuels and renewable energy sources except nuclear energy. Thus, it is timely to examine the landscape of Chinese energy and fuels.

China already publishes the world's second-highest number of published papers yearly, after the USA [4]. Accordingly, much attention has been paid to the studies coming from China. There were approximately 212,000 articles with the topic of China in the Science Citation Index Expanded (SCIE) database from 1900 to 2015. China's research performance, as measured using bibliometric methods with the topic of China, has also increased to about 260 papers. The first paper was “The sleeping dragon wakes up: a scientometric analysis of the growth of science and the usage of journals in China” published in 1993 [5]. Disciplinary studies of Chinese research in fields such as economics [6], chemistry [7], chemical engineering [8], biochemistry and molecular biology [9], neuroscience [10] and especially nanoscience and nanotechnology [11,12] have been conducted using bibliometric techniques. Additionally, many authors have focused on energy and fuel research in China [13–19]. For example, Yan et al. presented the status of China's road transport in terms of vehicles, infrastructure, energy use and emissions and provided comprehensive and appropriate strategies in the future [13]. A complete picture of China's energy situation in the new millennium was brought by Ma et al. in 2009 [14]. Liu et al. discussed solar energy of the distribution zone, current developmental situation and application, and the prospect of solar energy in China [15]. Lewis found that the carbon finance had played an evolving role in promoting renewable energy development in China published in Energy Policy [16]. Wang's study evaluated residue quantities and distribution of field crops in the 31 provinces of China mainland. They predicted that the total residue quantity for biofuel production could potentially reach 314 Mt in China [17]. Rout et al. addressed energy demands and emissions of China on the long term (to 2100) by key energy indicators. The results showed that China will require approximately 4 Gtoe of primary energy and results 10 Gt CO_2 emissions by the end of the 21st century [18]. Chen et al. calculated the environmental costs of coal by using input–output model and investigate the effectiveness of the Pigouvian carbon tax applied in developed and undeveloped resource-dependent provinces of China [19]. However, there were only a small number of bibliometric studies of energy and fuels research with topic of China, such as entitle “Way forward for alternative energy research: A bibliometric analysis during 1994–2013” [20] and “Mapping biofuel field: A bibliometric evaluation of research output” [21]. Despite the studies mentioned above, few studies aimed to obtain a comprehensive overview of energy and fuels research in China using bibliometric methods. For example, Haslam et al. assessed fuel cell vehicle innovation and the role of policy in Japan, Korea, and China [22], and Duan analyzed the relationship between international cooperation and scientific publications in energy R&D in China [23]. The characteristics of Chinese energy and fuels research have not yet been discussed. Many energy- and fuel-related issues, such as research priorities, remained unclear, and therefore, a comprehensive bibliometric analysis of China is necessary.

Priorities, topics and topic shifts can provide important insights into the research and map out directions for future researchers. Research priority can be indicated by a country's publishing output [24]. A country's publication of research in different fields of science is not accidental. It is the corollary of past resource allocations and policy decisions in the given fields [25]. Aside from traditional bibliometric methods, other bibliometric indicators have been used in research output analyses, such as international scientific collaboration [3,23,26] and patent analysis [22,27]. Author keywords provide more information about research topics; thus, author keyword analysis has been introduced in trend [28,29] and priority studies [25,30] based on keyword occurrence frequencies. In recent years, the changing distributions of keywords over time have been displayed in tables for different lengths of time, such as two [8], four [31], five [32], six [4] and ten years [30] and they have been used to evaluate research trends. If the interval being analyzed is insufficient, trends can be difficult to determine; in otherwise, trends may be obvious, but they cannot determine the most popular recent issues. Bubble charts compensate for these defects. They enable the rapid visual recognition of pattern changes [33,34]. Articles such as “Using a bubble chart to enhance adherence to quality-of-care guidelines for colorectal cancer patients” [35] and “Effects of an intervention on nutrition consultation for cancer patients” [36] are examples that used bubble charts. In recent years, bubble charts have been found to be simple and useful tools for comparison, but this graphical tool has not been attempted in previous bibliometric analyses.

This study aims to provide an overview of Chinese energy and fuels research based on data extracted from SCIE during 1993–2012. In particular, bubble charts were used to assess and evaluate both the 30 top keywords and the different Chinese institutions by year. Author keyword occurrence frequencies were comprehensively analyzed for different ranges of time, such as twenty years and ten–five–five years. Five bibliometric indicators were employed to analyze document types and languages, annual published document outputs, institutions, journals and international collaborations.