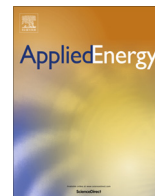




Contents lists available at ScienceDirect

Applied Energy

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

Assessment on the research trend of low-carbon energy technology investment: A bibliometric analysis

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HIGHLIGHTS

- Literature about low-carbon energy technologies investment is obtained.
- Distributions of geography, journals, subjects etc. are analyzed.
- Auctorial, institutional and national collaboration are given.
- Productive authors and institutions and the most cited articles are gotten.
- National comprehensive strength and hot topics are figured.

ARTICLE INFO

Article history:

Received 28 January 2016

Received in revised form 30 May 2016

Accepted 28 July 2016

Available online xxx

Keywords:

Low-carbon energy technology

Energy investment

Bibliometric

Frequency analysis

ABSTRACT

Based on databases of Science Citation Index Expanded (1981–present) and Social Sciences Citation Index (2002–present), this paper applies the bibliometric method to analyze the scientific publications of low-carbon energy technology investment. By characterizing the basic information of the publications, we found: the historical development process is clearly divided into two stages; the field of low-carbon energy technology investment has entered a stage of rapid development; the strength of developed countries is far greater than that of developing countries; the comprehensive strength of the United States ranks the first in the field, followed by UK and Denmark and only China and Turkey are developing countries among the top 15 countries; the auctorial collaboration degree in this field shows a clear upward trend, but institutional and national collaboration degrees are steady and relatively low. In addition, distributions of geography, journals and subjects, productive authors and institutions, frequently cited articles, etc. are obtained: articles in this area are mainly distributed in the USA, several countries in Europe and China; the most productive journal, author and institution are Energy Policy, Lund H from Denmark and National Technical University of Athens in Greece; Energy Fuel is the most popular subject among all the outcomes; the most frequently cited article is written by Demirbas published in Energy Policy in 2007. According to the frequency analysis of keywords, it reveals that: “renewable energy” is a kind of keyword used most frequently; “carbon capture and storage technology” is an emerging keyword which is increasingly concerned about; scholars pay widespread attention to electricity issues, especially the feed-in tariff; the policy mainly includes energy policy and climate policy; the real option theory is the most widely used theory; the existing uncertainty is summarized as the cost uncertainty and policy uncertainty. In the end, several suggestions for the future research are given.

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1. Introduction

Climate change has been widely discussed in these years and it is agreed that the greenhouse gas emissions are mainly from anthropogenic activities, which needs the whole world to take actions urgently [1]. How to achieve the dual objectives of

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combating climate change and satisfying the increasing energy demand requires a wide range of measures. The low-carbon energy technologies are effective means to reach the above goals because they not only reduce the carbon emissions from the energy consumption fundamentally, but also secure the energy supply. At the meantime, many nations have set reduction targets for carbon dioxide emissions to cope with climate change [2–6]. To achieve targets of emissions reduction and the low-carbon energy system, investment in low-carbon energy technologies is essential. Generally, the low-carbon energy technology consists of three types [7]: improving the energy efficiency and conversion rate, such as IGCC power generation; alternative fuels, such as renewable energy, nuclear energy and low-carbon fossil fuels [8–10]; capture and storage greenhouse gases generated from fossil fuel. As a consequence, low-carbon energy technology investment issues are also concentrated on these three aspects, particularly on renewable energy technologies and carbon capture and storage (CCS) [11].

Until now, a large number of publications on low-carbon energy technology investment have emerged [12–17]. Previous studies were reviewed from different perspectives by a handful of scholars. Zeng et al. explored the status quo of China's renewable energy investment and financing in detail based on the overview of five perspectives: investment situation, investment and financing bodies, investment and financing means, sources of funding and financing channels [18]. Stambouli et al. provided an analysis of the existing renewable energy sector and a prediction for demand growth, additional capacity and investment requirements [19]. They also discussed the current energy scenario and explored the alternative energy like solar and wind to ensure energy security supply, reliability and higher efficiency in energy conversion, transmission and utilisation. Banos et al. presented a review of the current state of the art in computational optimization methods applied to renewable and sustainable energy and also presented a vision of the latest research advances in this field [20].

As a tool of quantitative analysis of the literature, the bibliometric method has been widely used to assess the performances of various disciplines [21,22]. Kiriya et al. integrated citation network analysis and bibliometric method to illustrate an overview and trends in nuclear energy technology and related fields [23]. In addition, they also compared the global trends of nuclear energy research and the differences of research conducted in universities and institutes in Japan. Wei et al. utilized the bibliometric method to summarize the important research topics and methodologies in the field of climate policy modeling based on the dataset of SCI-E and SSCI. In recent years, bibliometric analysis was employed in research of the energy field [24]. Sanz-Casado et al. conducted a bibliometric analysis of scientific publications on solar energy in Spain and Germany based on Web of Science data. The main conclusion of the work was the divergence in Germany and Spain between solar energy demand/output growth and the growth of research papers on the subject, which was linear [25]. Since China has invested largely in energy-related research and commercialization, through the review of intergovernmental cooperation programs and the bibliometric analysis of the top energy journals, Duan found that intergovernmental cooperation and non-governmental cooperation were two effective channels for energy R&D, but for different areas, the degree of cooperation was not the same [26]. Montoya et al. assessed the contributions of specialized publications from Spanish institutions in the energy field using the Scopus Elsevier database as well as the bibliometric analysis [27]. Kiriya and Kajikawa offered a bibliometric result on energy security from the perspective of status and trends in the academic publications. It indicated that research focus in energy security has changed from ensuring the self-sufficiency of the primary energy through promoting strategies to diversification of the secondary energy supply chain by introducing energy networks including

an infrastructure established through international coordination [28]. They analyzed different aspects of the publications, for instance, publication type, field, language, subcategory, journal type, the key word occurrence frequency, international collaboration and the most active categories and concluded that Spanish research was an important and relevant player in the international scientific scene.

It is beneficial and necessary to understand the current research situation, research hotspots and future development trend in the field of low-carbon energy technology investment by sorting out and summarizing the existing literature [20]. However, to the authors' best knowledge that there is no previous work which focuses on trying to solve this issue comprehensively. To make a contribution to filling the gap in the existing studies, we conducted the work from the following aspects. To begin with, the bibliometric method is applied to investigate the latest research status and trend, including the quantity of articles, distributions of geography, journal and subject, productive authors and institutions, academic collation and article citations. In addition, the comprehensive strength between countries is also measured. Second, the frequency analysis of keywords is applied to discover the hottest research topics in this field. Finally, several suggestions regarding of future low-carbon energy technology investment research are given in the conclusion based on the above results.

To sum up, this paper shed light on the current research in the following points: (1) it is the first try to summarize and assess the research trend in the field of low-carbon energy technology investment (2) based on the frequency analysis of keywords, the current hot topics are clarified, which provides scientific reference for the future research (3) we conclude the potential research directions according to the summary of the existing literature, which makes a contribution to the future development as well as the research progress of low-carbon energy technology investment.

2. Materials and methodology

The data were collected from databases of Science Citation Index Expanded (SCI-E, 1981–present) and Social Sciences Citation Index (SSCI, 2002–present) compiled by Thomson Reuters. 2121 articles whose topics (titles, keywords and abstracts) contain two types of words, i.e. “low-carbon energy technology” and “investment” were obtained on March 21, 2014. We set the document type and language as “article” and “English”, respectively. The results¹ provided abundant information and the personalized export option were used. Referring to the previous works [21,24,25,27], we selected the following terms to conduct the analysis:

General statistics, such as the quantity of articles, distributions of geography, journal and subject, productive authors and institutions, academic collation, article citations and comprehensive strength. Through the mentioned terms, the latest research status about low-carbon energy technology investment was estimated, which is of benefit to policymakers and researchers who are interested in this field by helping them learn the general situations quickly and provide relevant references on their publications.

Research hotspots. Keywords of one research reflect what the authors are concerned about, so frequency analysis of keywords was used to investigate the research hotspots and trends in the field [29] and this method has been applied in quite a few previous studies [30–32]. This paper analyzed the frequency of keywords and summarized hot topics and future trends, which may influence scholars' future study selections.

¹ It should be noted that we did not clarify the papers in terms of science and engineering and social science in this work.

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