Renewable and Sustainable Energy Reviews 57 (2016) 226–237

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

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

A topic modeling based bibliometric exploration of hydropower research

Hanchen Jiang, Maoshan Qiang*, Peng Lin

State Key Laboratory of Hydroscience and Engineering, Tsinghua University, Haidian, Beijing 100084, China

ARTICLE INFO

Article history:
Received 28 February 2015
Received in revised form
10 September 2015
Accepted 17 December 2015
Available online 4 January 2016

Keywords:
Hydropower
Renewable energy
Bibliometrics
Topic modeling
Research trends

ABSTRACT

Scientific research articles can provide rich insights into practitioners' viewpoints around contentious policy making. Although much attention has been paid to hydropower development in the literature, few of them gathered systematic data and performed a large-scale review of scientific articles. In this study, we employed a topic modeling based bibliometric analysis to quantitatively evaluate global scientific literature of hydropower, with a time frame from 1994 to 2013. We analyzed 1726 scholarly articles highly related to hydropower, to discover the research development, current trends and intellectual structure of hydropower literature. Common bibliometric indicators show that hydropower research publications sustain a rapid growth rate, English is the dominant language, and the hotspots of hydropower research can be concluded as "fish", "species", "climate", "emission", "lake", "sediment", "Turkey", etc. We established a 29-topic model to describe the intellectual structure of the 1726 articles, and employed cluster analysis and trend analysis to process the derived topics. We find that post construction issues of hydropower are more attractive for scholars than construction technology itself, and an interdisciplinary trend of hydropower research is emerging. The methodology reported in this study is expected to gain traction as a methodological strategy for energy research reviews and subsequently to promote energy policy making.

Contents

* Corresponding author. Tel.: +86 15210587279; fax: +86 10 62782027.
E-mail addresses: jhc13@mails.tsinghua.edu.cn (H. Jiang), qiangms@mail.tsinghua.edu.cn (M. Qiang), celinpe@tsinghua.edu.cn (P. Lin).

http://dx.doi.org/10.1016/j.rser.2015.12.194
1364-0321/

1. Introduction

Worldwide urbanization is stimulating a rapid economic growth together with an increasing demand of energy [1], as energy is the prime agent in the generation of wealth and a significant factor in economic development [2]. However, current trends in energy supply and use are unsustainable economically, environmentally and socially. As traditional fossil fuels still account for a major part of the total energy consumption, greenhouse gas (GHG) emissions caused by usage of these fossil fuels will result in serious consequences including global warming, acid rain, air pollution and many extreme weather disasters [3]. In order to address the global challenges of increasing energy demand, energy security, climate change and sustainable development, there is a pressing need to accelerate the development of renewable energy technologies. Currently, investments in renewable energy sources, including biomass, hydro, geothermal, marine, solar and wind, significantly contribute to the realization of environmental and governmental objectives [4], because renewable energy sources produce zero or almost zero emissions of both air pollutant and GHG [5], and have higher energy security in the face of uncertain markets for traditional fossil fuels [4]. According to the World Energy Outlook 2013 [6], there is a rapid increase in the use of renewable energy, in particular in the power sector. The share of renewable energy in total electricity generation has risen to 20% in 2011, from 15% in 2006, and will rises to 31% in 2035 under the New Policies Scenario [6].

Of the various renewable energy sources, hydropower is the largest one, generating about 3500 TW h (terawatt-hour) electricity in 2011, accounting for 16.3% of world's electricity, more than nuclear power (12.8%), far more than wind, solar, geothermal and other renewable sources combined (3.6%), but still much less than fossil fuel plants (67.2%) [7]. Under the New Policies Scenario, in order to achieve the predicted share of renewable energy in total energy consumption in 2035, major efforts need to be devoted to continuously developing hydropower in the coming decades. Hydropower is fully mature in technology, because of the early development of hydropower projects in many parts of the world. Compared to other renewable energy sources and traditional fossil fuels, hydropower has several advantages, including a high level of reliability, high efficiency, low operating and maintenance costs, flexibility and large storage capacity [2,8,9]. In addition, some large hydropower projects, such as the Three Gorges Project (TGP) in China and the Itaipu Project in Brazil, are usually integrated with other multiple functions including flood control, navigation, and water supply [9,10]. The huge undeveloped potential is another incentive of continuous practice together with research in hydropower sector. The worldwide technical potential for hydropower is usually estimated at around 14,576 TW h per year [11], or about 35% of a theoretical potential derived from the total annual runoff of precipitation [12]. Although there is a long history of human developing hydropower, the percentage of installed technical potential is still low (25% of the total technical potential). From a regional perspective, the percentage of undeveloped technical potential is highest in Africa (92.0%), followed by Asia (80%), Oceania (80%) and Latin America (74%). Even in the most industrialized parts of the world, the undeveloped potential is still significant, at 61% in North America and 47% in Europe [7]. Considering the comprehensive benefits and huge developing potential of hydropower, many countries, such as China [13], Turkey [11], India [14] and Brazil [15], give priority to hydropower development.

However, many serious problems, including environmental issues, socio-economic issues, public acceptance and financing, constraint the development of hydropower projects. Taking the world's largest hydropower project, the TGP, as an example, these four problems are significant during both the construction and operation periods of the project. Environmental impacts of the TGP include an increase in geological risks such as earthquake and landslides [16], water body pollution [17], disruption of the riparian ecosystem [18] and unstable reshaping of the whole Yangtze River system [19]. The socio-economic impacts mainly resulted from the 1.2 million involuntary immigrants [20]. Their survival and developmental issues are of significance to the project success and the social stability. The public acceptance problem of the TGP arose in 1989, when one-tenth of the delegates to the National People's Congress (NPC) signed a petition demanding that the development plan of the TGP should be prudently revised to eliminate negative impacts as much as possible [21]. And in 1992, at the formal vote to approve the project, 1767 delegates voted in favor, 177 delegates opposed the project and 644 abstained [22]. From the beginning of the construction in 1994, the debate of the TGP in China has never stopped [23]. In addition, currently, with the development of social media websites, more and more people discuss public issues through the internet [24], making the public relation problem of a large hydropower project more complex. The financing of the TGP is relatively smooth. The total investment of the TGP is about 200 billion China Yuan, among which 40% is from the TGP Construction Fund, and 20% is from the generation revenue of Gezhouba hydropower station and the TGP itself during construction. The remaining 40% of capital is from the financial market. However, the point is that the TGP Construction Fund was raise from all citizens in China by adding a levy of 0.007–0.015 China Yuan per kilowatt-hour on residential electricity tariffs from 1992 to 2010 [25], leaving a defect which may trigger public dissatisfaction with the project. As a matter of fact, most of these problems with the TGP are commonly existing in hydropower projects all over the world. Unique problems are also found in different hydropower projects, due to the differences in natural and social conditions.

The importance and complexity of the hydropower development issues has attracted scholars across different disciplines, including energy science, hydrology, civil engineering, environmental science, ecology, engineering economics, social science, etc. Although much attention has been paid to hydropower development in these years, few studies attempted to perform a large-scale review of academic articles related to hydropower. An important function of scientific research is that it plays a critical role in identifying many contemporary public policy problems. This function satisfies the increasing requirement of science in the so-called rational decision-making [26]. Science and policy are intimately intertwined. Attempts of making more rational policy necessitate constructing intellectual frameworks of relevant scientific research. Hence, in order to help deploy a rational hydropower development strategy, we performed a topic modeling based bibliometric exploration of peer-reviewed literature reflecting the global status and trend of hydropower research with 1726 target articles published from 1994 to 2013.