



The rapid bi-level exploration on the evolution of regional solar energy development



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HIGHLIGHTS

- Bi-level networks are classified.
- Economic region are used to explain the results.
- Practical information is explored as the market feedback.
- Combined approaches are used to quickly acquire information.
- Visualized evolution of local solar energy development in China is provided.

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ABSTRACT

As one of the renewable energy, solar energy is experiencing increased but exploratory development worldwide. The positive or negative influences of regional characteristics, like economy, production capacity and allowance policies, make them have uneven solar energy development. In this paper, we aim at quickly exploring the features of provincial solar energy development, and their concerns about solar energy. We take China as a typical case, and combine text mining and two-actor networks. We find that the classification of levels based on certain nodes and the amount of degree avoids missing meaningful information that may be ignored by global level results. Moreover, eastern provinces are hot focus for the media, western countries are key to bridge the networks and special administrative region has local development features; third, most focus points are more about the application than the improvement of material. The exploration of news provides practical information to adjust researches and development strategies of solar energy. Moreover, the bi-level exploration, which can also be expanded to multi-level, is helpful for governments or researchers to grasp more targeted and precise knowledge.

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1. Introduction

The global fossil energy crisis and the requirements of pollution remission faced by most countries have promoted the development of renewable energy [1]. Thus, in recent years, solar energy has received significant attention from not only governments but also the public [2], and has got vigorous development prospect in the production and the application.

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However, because of limit precedents of renewable energy, the development of solar energy is still in the exploratory stage. In fact, although lots of academic studies and research institution has made significant contributions to the material improvement of solar cells [3–5], distributed electricity generation [6–8], the ecological relation between solar energy and urban development [9–13], practical applications are still lagging compared with them, having to deal with conflicts with reality. As a result, acquiring the information on the development in solar energy utilization is instructive for both the realistic application and further studies. However, the utilization is affected by many exterior factors, like geology, economy or production capacity. It means that, for a certain country, different regions with their own characteristics have their own concerns on solar energy utilization. Especially for China, whose regional differences are apparent, its solar energy development is unevenly distributed across all provinces. As a result, as a typical case, the quick exploration of practical information on Chinese regional solar energy development is essential, which can be references for the governments to make or adjust their policies.

The evolution of regional solar energy development has become the focus point for researchers. C.L. Kwan [14] explored the distribution and influence elements of PV in the United States; A.M. Adil [15] provides general analysis on the renewable energy systems evolution from a socio-technical perspective; O. Yetemen [16] selects the ecohydrologic perspective to analyze their landscape evolution. These studies provide abundant information with technical, authentic or professional measurement, but few take the market as a whole to explore the application condition. As a result, our research tends to know the provincial solar energy development characteristic with a rapid exploration method.

To quickly grasp the general situation of a certain field [17,18], text mining has been widely used in previous studies. In contrast to academic articles which describe technological developments, news represents the timely communication of practical information [19]. In particular, news titles are the most direct and precise reflection of entire news articles, thereby providing an easy way for readers to quickly obtain the important points of the article. This type of text can reflect not only the real application and development of solar energy but also concerns from the public.

However, the information in the text is abundant but complex, thereby contributing to its unstructured characteristics. To solve this problem, the complex network, which has been widely improved for broader application [20,21] or used on energy issues [22,23], is useful for analyzing the features of each object and the relations among them [24,25]. In particular, two-actor networks can effectively explore information between two sets of objects with different attributes [26]. For example, they can be used to study the relations between energy companies and their shareholders [26] or between ethnic violence and other factors such as environmental resources or social-political terms [23]. These studies, which apply two-actor networks to the text mining have demonstrated that this method is useful for quickly obtaining required information [27]. These papers focus on the feature and evolution of the entire pattern [28]. However, local information represents a fresh perspective for exploring concentrated features of required objects. Thus, our work combines two-actor networks with text mining to study regional solar energy development in China from the perspective of both global and local evolution features as the two different levels.

Our work aims at quickly extracting practical and targeted information for energy issue, especially the renewable energy market. We use news titles as data source, and two-actor networks between the set of regional nouns and non-regional nouns have been constructed as the models. First, we make general analysis on the global features of bi-level networks, including the pattern scale and controllability. Then, we explore top 10 hot provinces that are mentioned by most news articles many times to explore provinces that receive substantial attention from the media and the public. Top 10 key provinces are also explored as the bridge for the network construction. Moreover, closeness among provinces is measured, and the local information from the relation between two levels is given to differentiate key development aspects for each province.

The remainder of this paper is organized as follows. The next section introduces the data source and the methodology. Section 3 analyzes provincial solar energy development from global and local information. Section 4 presents a discussion, and Section 5 concludes this study.

2. Data and methodology

2.1. Data

2.1.1. The data extraction

We obtained our data from the Chinese Energy Website (<http://www.china5e.com/new-energy/solar-power/>). Not similar with some common Chinese search engine, the Chinese Energy Website is a professional one with the collection of all energy-related news and information, especially focusing on the practical application of energy. As a result, the data collection from this website corresponds with our research goal with relative low amount of noisy data.

For the data extraction, the selected toolkit in this research is LocoySpider (<http://www.locoy.com/>), which is a commonly used one to collect online textual data. Because there is a specialized news board about solar energy development, we directly extract all news titles in this news board from 2010 to 2014. A total of 16893 pieces of news titles provide 70288 valid relations among words. Data for each year constitute a data set. Thus, we obtain five data sets and study on them individually.

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