Which one is the most hopeful successor of main energy source after coal, petroleum and natural gas?

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Abstract

In past a few centuries, the main natural resources are coal, petroleum and natural gas, which are applied in whole world more and more but cannot be regenerated. Today's scientists focus on some new natural resource and hope them became the successor of that old natural resource. This article is to answer the question that which one is the most hopeful one, water power, nuclear, solar power or wind power. The method is to compare the number of publications production between the old nature resources and new nature resources and find out the rule of development. The data sources are EI Compandex from 1969 to 2005 and SCI from 1995 to 2005. The analysis is based on the relevant data about each kind of resource, such as total number of papers and their region distribution, international coauthored number, this article analysis the regularity in the number, distribution and trend of development. At the same time, this article also examines the data regarding international cooperation publications to discuss the role of collaborations in the resource field development.

1. Introduction

On February 9, 2006, the State Council of China issued the guidelines on national medium- and long-term program for science and technology development (2006-2020). The program lists 11 major sectors in which China will give priority to technological development in coming 15 years.[1] Energy source is the first one in the 11 major sectors, it means that as one of the world's largest energy producers and consumers,[2] China is facing the urgent need of energy source to improve economy development and ensure national safe. In past a few centuries, the main natural resources are coal, petroleum and natural gas, which are applied in whole world more and more but cannot be regenerated. Which one renewable resource is the most hopeful successor? This article tries to answer the question by comparing the distributions and collaborations of publication between three old nature resources, (coal, petroleum and natural gas) and four new nature resources (water power, nuclear, solar power or wind power). The continually growing of the number of whole publications, under this background, the number of publications in such seven fields keeps increasing year by year,

but different grown rule are shown in each filed. Some bibliometricians have found that if there are more publications in a particular area compared to another, it means more resources and more facilities in that particular area compared to the other. [3] Similarly, we can find that the rule about the country and region distribution of share of publications imply the publications output fasten on few main countries and regions or spread around, the coloration data can show concurrent result. .. At the same time, this article analysis the distribution of document type and language and explain the characteristic in each field.

2. Data

Energy is a typical engineering subject, so we select Ei Compendex as the main dada source to analyze the distribution of publications. The range of calculated Ei data is from 1969 to 2006 Feb. From the interface of Ei database (Engineering Village 2), we can search via the thesauri, which is guides to the controlled vocabulary used in indexing articles for Compendex. Indexers choose terms from the controlled vocabulary to describe the content of the articles they index. The controlled vocabulary is used to standardize the way the articles are indexed, and ensures consistency and accuracy in search retrieval. The Compendex thesauri are hierarchical in nature. Terms are organized by broader, narrower or related concepts. Articles are indexed using the most specific controlled vocabulary terms available. [4] By the way we can define the exact term of each field and .get the search command which include term words from the "search box".

The author affiliation in Ei database is not so complete as SCI database, so it is difficult to analyze the author collaboration with Ei data. To resolve this question, we select SCI as the substitution. Its range is from 1995 to 2005. We set the exact term defined in Ei Compendex as key words to search in SCIE.

3. Comparison

3.1. Number and share of publications production

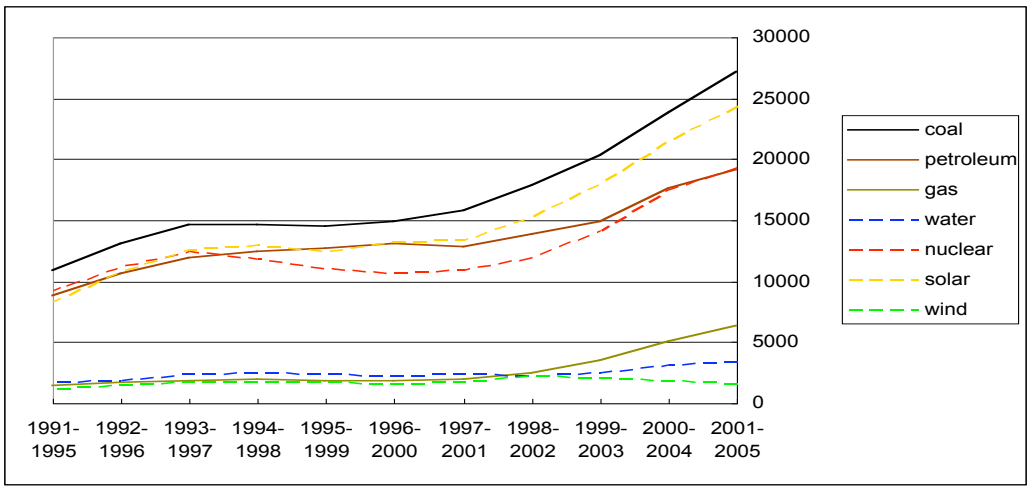

Fig. 1: The number of publications

From Fig.1 we can find that the number of publications in these seven fields keeps increasing year by year . The data source of this figure is Ei Compendex. The real lines express old nature resources, and the broken lines express new nature resources.

There are more publications about solar power and nuclear power and their numbers increase fast er than hydro power and wind power. Especially in solar power, it keep same development as petroleum and better than coal and natural gas.

Fig.2 shows the share of publications in the decade from 1995 to 2004. The data source of this figure is Ei Compendex. These lines except natural gas and wind power are nearly superposed together, the share of publications in each field are under 10% in 1995 and about 15% in 2004. We can find the output of the field of wind power is very different from other field.

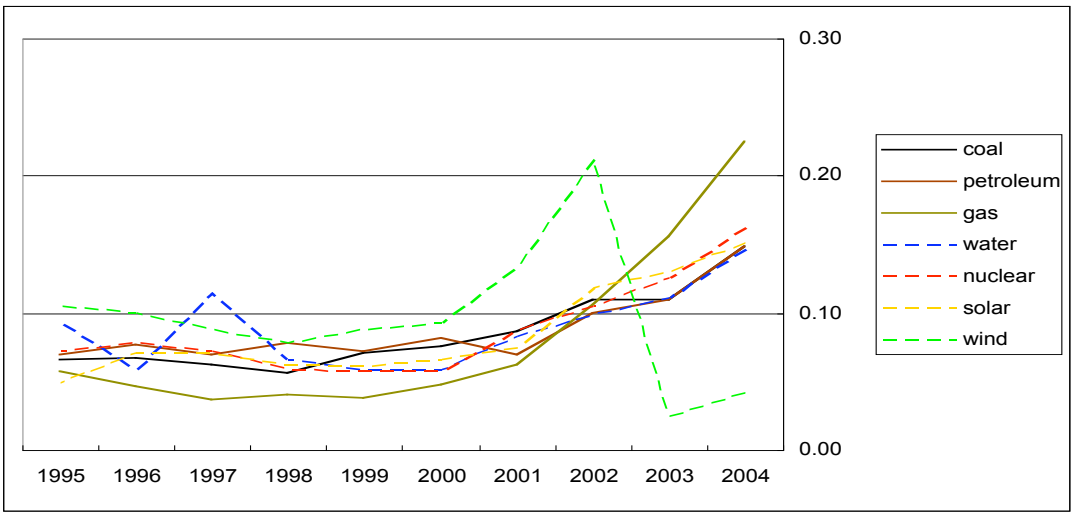

Fig. 2: The share of publications

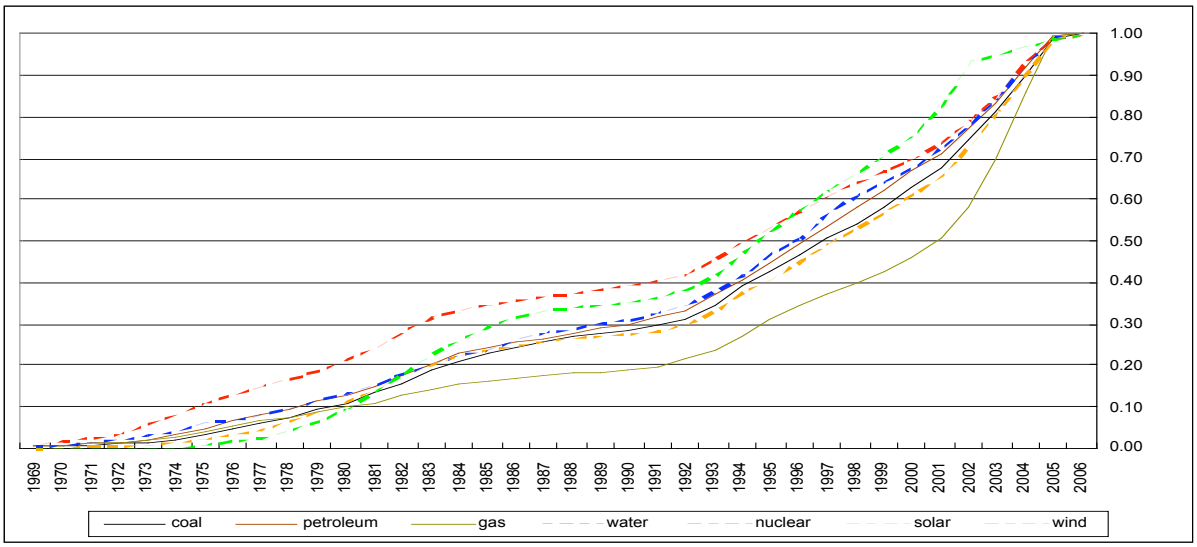

Fig. 3: The accumulative share of publications 1969-2006

Fig. 3 shows the accumulative share in a long term from 1969 to 2006. It can be found that the lines of solar power and water power along the very similar track with lines of petroleum and coal. From the state of line, we can know that share of nuclear publications increase faster in the range 1970-1980 and the share of wind power publications increase faster in the range 1981-1985.

3.2. Distribution

We rank the top 60 countries and regions according to the respective number of publications in each field, and examine the share of these countries and regions, then arrange countries and regions in different range of share. For example in solar power field, there are 2 countries and regions whose share of publication is more than 10%, and there is 1 countries and regions whose share of publication is between 5% and 10%; and there are 13 countries and regions whose share of publication is between 1% and 5%; etc. Fig.4 show the distribution of top 60 share countries and regions in each field. We can find that in solar power field, there are more countries and regions which share high rate of publications, it means that more output of publications in this filed widely distribute in more countries and regions.

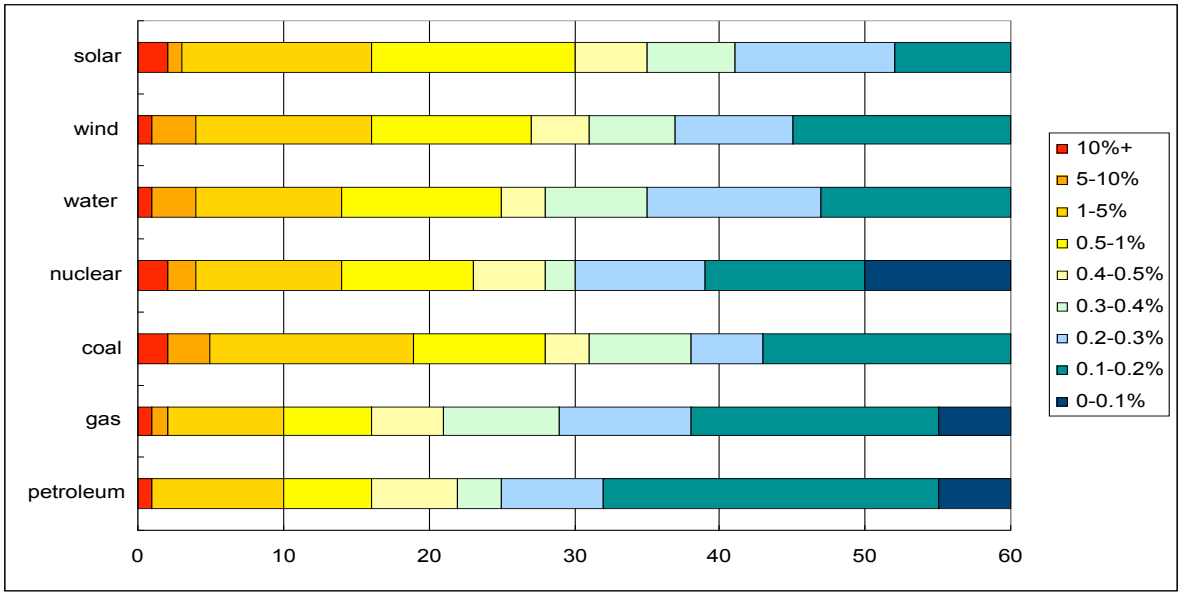

Fig. 4: The distribution of top 60 countries and regions in the number of publications

Some bibliometricians have found that there exists a negative power function relationship for rank-frequency distribution of publication. [5] In this research, we exchange the frequency with share. This is to say, general formula $y=x^{-}$ holds, where y is the share of publications, x is the rank of a country of region and -_ is a constant. In Fig.5, the seven lines show different field, if _ is high in one field, it means there few countries productive more publications. We can find that in solar field, _ is 0.0323, which is lower than _ in wind power and water power, and in nuclear power field, _ is 0.0403, which is higher than it in any other field, so we can

know there are more widely research in solar power and more narrowly research in nuclear power.

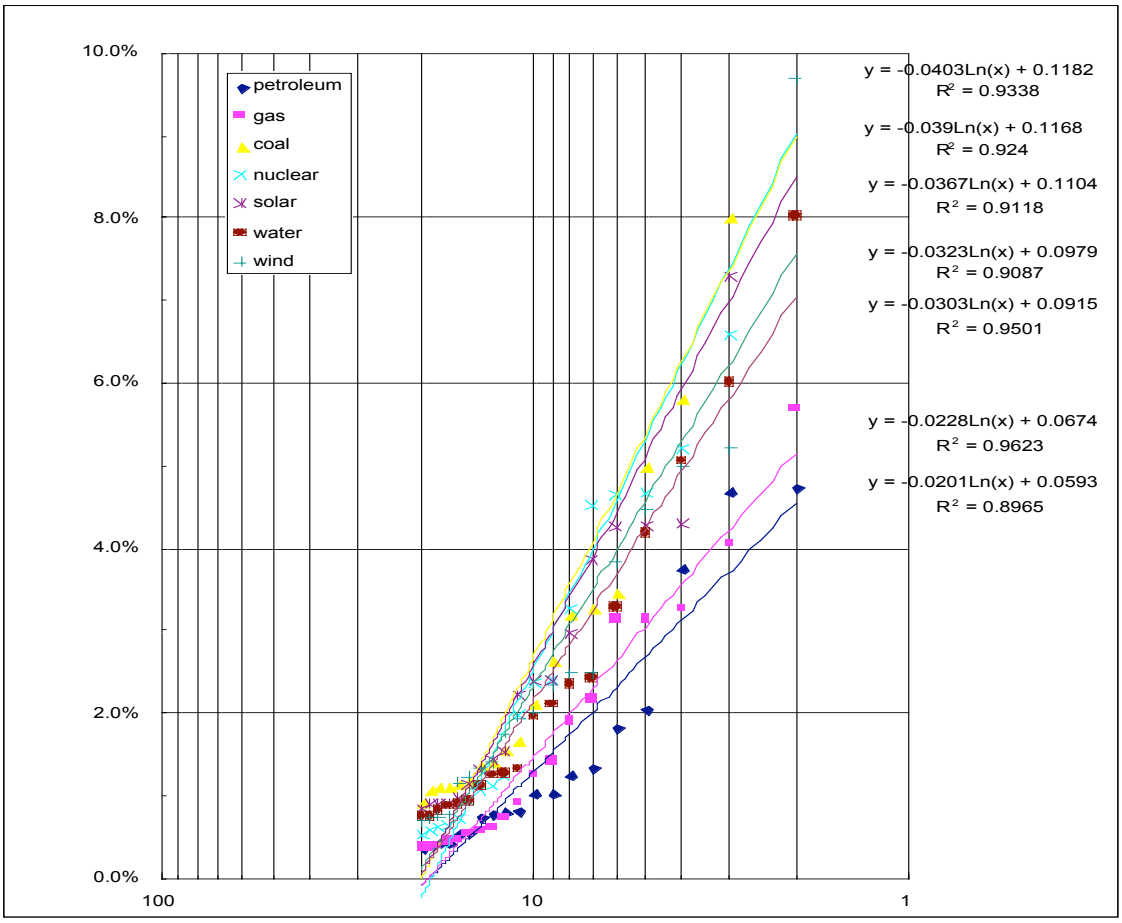

Fig. 5: The rank-share relation of top 20 countries and regions about the share of publications

In Ei Compendex, the dominant type of publications is Journal Article while about 22% [4] is Conference article. From Fig.6 we can find the rate of conference article is more than 22% in each field except coal.

In Ei Compendex, most publication were written in English whose share is about 90%. [4] Fig 7 show the distribution of publications in six main language: English, Russian, Chinese, German, French and Japanese. We can find in Solar power field, the rate of publications in English is obviously higher than it in other field.

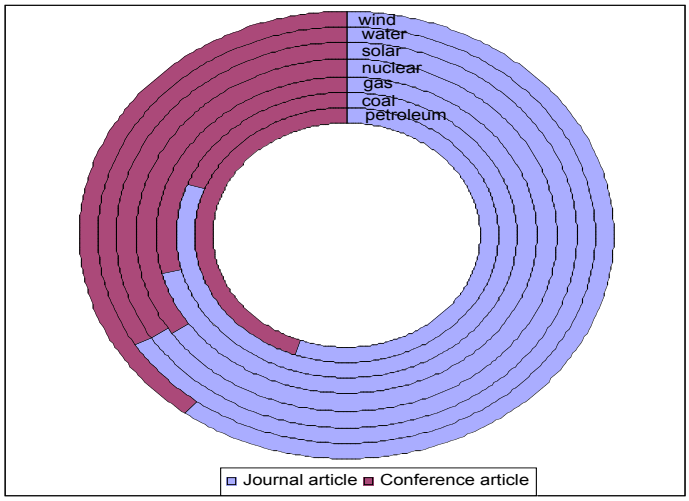

Fig. 6: The share of journal article and conference article

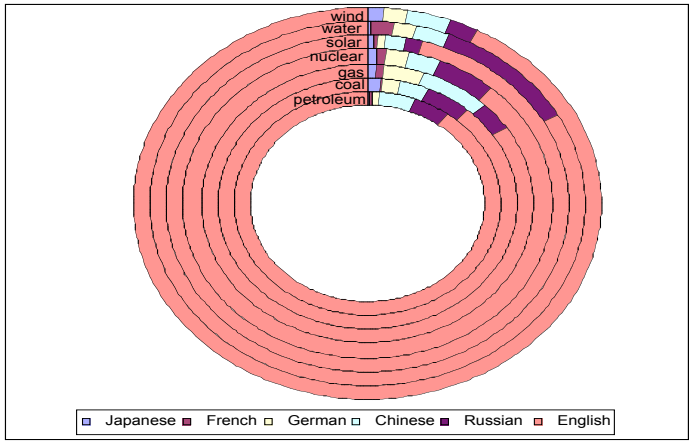

Fig. 7: The share of 6 main languages

3.3. Collaboration

The following analysis about collaboration is according to SCI data.
Fig. 8 shows the share of publications completed through independent, local collaboration, with authors coming from same countries or regions, or through international collaboration. We can find that in solar power field and water power field, the percent of collaboration publications including both type of collaboration is more than 40% and more than it in other field. At the same time, the percent of international collaboration publications in water power field is the highest one more than 20%.

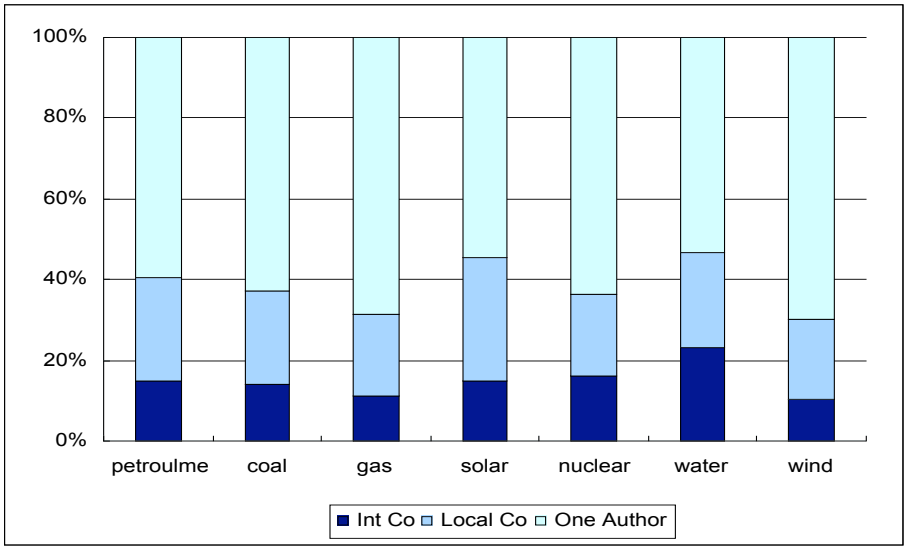

Fig. 8: The share of independent and coauthored paper

Fig. 9 shows the share of amount of author in coauthored publications. In nuclear power field, there is higher percentage of publications with multiple authors than it in other fields. At the same time there are lower percent of publications with mass authors than it in other field

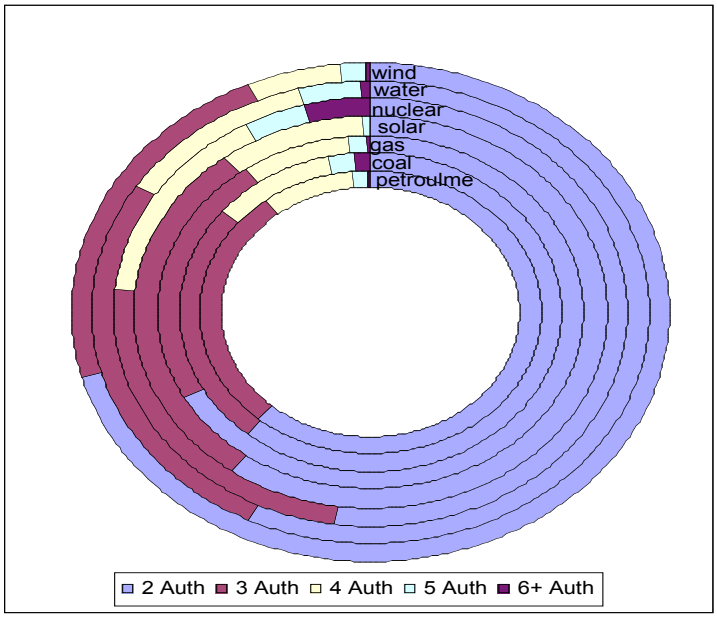

Fig. 9: The share of amount of author in coauthored papers

Fig. 10 shows the share of amount of partner country in international coauthored publications. We can find the similar distribution as Fig 9 that in nuclear power field, there are higher percent of publications with mass partner countries and regions than it in other field.

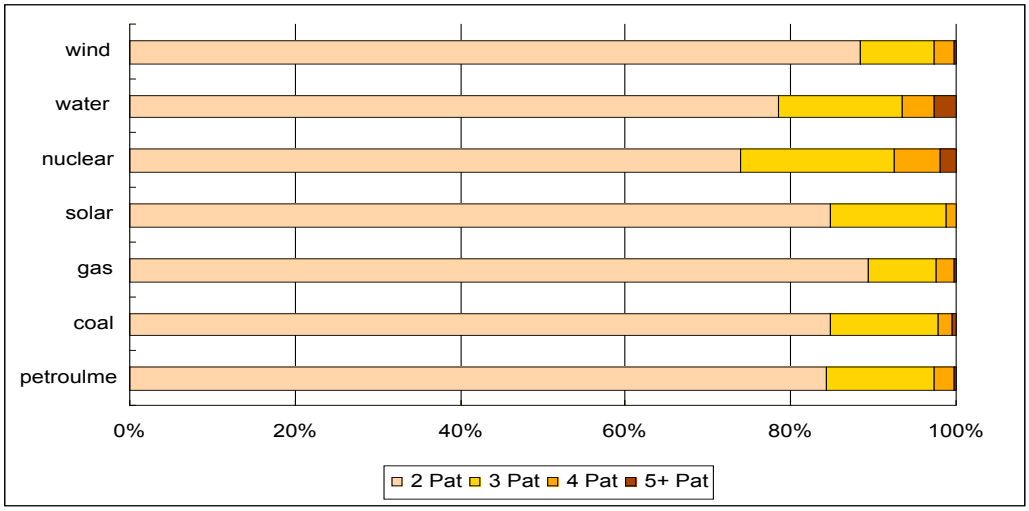

Fig. 10: The share of amount of partner country and region in international coauthored papers

From Fig.11, we can find that the general trend of rate of coauthored publications is increase from 1995 to 2005, and the rate in solar power field and in water power field grows faster.

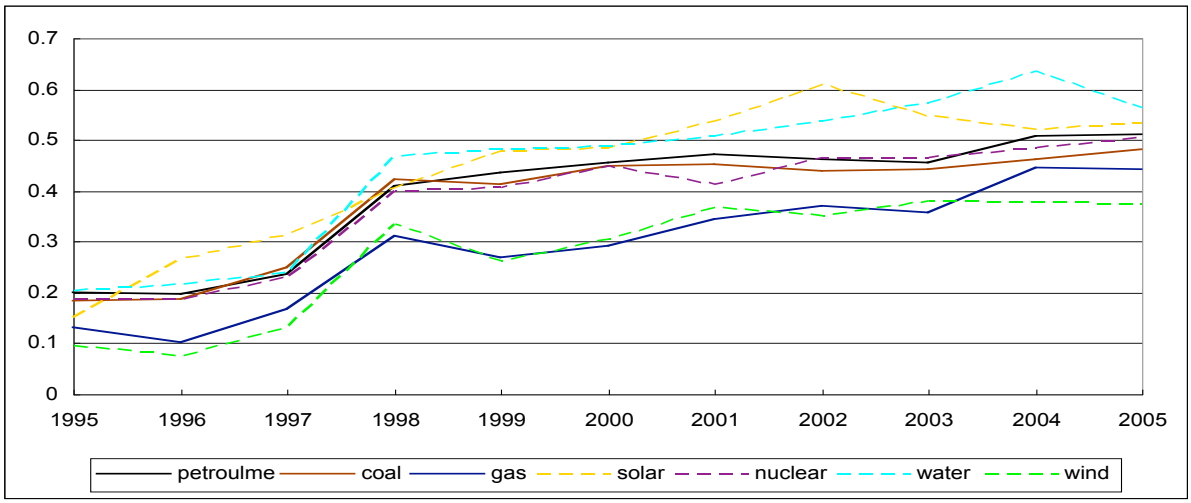

Fig. 11: The rate of coauthored papers

4. *Discussions*

4.1. *Solar power may become the hopeful successor*

According to the comparison in the number and share, distribution and collaboration of publications in the seven field, we can find that in solar power field, there are more

publications produced, and the growth track keeps the same pattern as that in the old energy source. From the analysis to distribution, we can also find there are more countries and regions product more publications in solar field, it means that more country focus on this field and carry on deep and wide research. From the data about collaboration, it is obvious that the percent of collaboration publication is high and keeps increase. Integrating these analysis, we think the answer of the question in title maybe is solar power.

4.2. More work to be done

To research a topic about output in engineering field, the data of patent is important, but it is not covered in this article. Additionally, we are going to make extrapolation with the data by time series to predict the publications development trend in energy field.

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