RESEARCH REVIEW JOURNALS
Volume-03
Issue-10
October-2018

ISSN: 2455-3085 (Online)
RESEARCH REVIEW International Journal of Multidisciplinary
www.rrjournals.com [UGC Listed Journal]

Research Output Analysis on Solar Power Generation: A Scientometric Study

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ARTICLE DETAILS

Article History
Published Online: 10 October 2018

Keywords
Solar Energy, Solar Power, Solar Power Generation (SPG), Authorship pattern, Scientometric Analysis

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ABSTRACT

The aim of this article is a scientometric analysis of solar power generation covers 20,119 records from scopus database during the study period 2008 - 2017. These articles find out year wise growth of literature, author productivity, bibliographic distribution, country wise contribution. Further authorship pattern, the degree of collaboration are analyzed. Country-wise distribution reveals that 4,153 (16.41%) records are published the United States with highest in the year 2015 at 732 records, followed by China 3,737 (14.78%), Indian rank in 3rd with 1,904 (7.52%) records and highest in the year 2017 at 614 records. The average degree of the collaborations is 0.94.

1. Introduction

Solar Energy is one of the mainly important renewable energy sources that have gained improved attention in recent years. Solar Energy is a very large endless of energy. Solar Energy is overflowing it has the greatest availability compared to other energy sources. The amount of energy supplied to the earth in one day by the sun is enough to power the total energy needs of the earth for one year [1]. Solar Energy could supply all the present and future energy needs of the world on a long-term basis [2]. This makes it one of the most capable of the unconventional energy sources. Solar Energy is a clean and free release since it does not generate pollutants or by-products harmful to nature.

2. Review of Literature

K.C. Garga and H.K. Tripathi (2018)[3] have analyzed the contents of the published articles in terms of various disciplines and sub-disciplines of the bibliometric aspects discussed in these articles. The analysis of 902 papers published by Indian scholars during 1995-2014 indicates that the main focus of bibliometrics/scientometrics is on assessment of science and technology in India followed by analysis of individual journals. The analysis of data indicated that the share of theoretical studies using and statistical technique which was missing in the earlier period (1970-1994) has increased during 1995-2014. The field of medicine as a discipline received the highest attention as compare to other disciplines.

Bharvi Dutta and Khaiser Nikamb (2014) [4] have, examine this study, look into collaboration in solar cell research in India as reflected by the publications indexing Web of Science for a period of 20 years from 1992-2010. Almost half of the total output emerged out of domestic and international collaboration. Academic institutions had an almost equal proportion of output emerging from the domestic as well as international collaboration. Among the prolific Institutions, National Physical Laboratory-Delhi of the Council of Scientific and Industrial Research had the highest publications emerging out of collaborative research. Indian researches collaborated with their counterparts in 31 countries; however, South Korea, Japan, USA, Germany, England, France, and Greece were dominant collaborating research partners. Research Collaboration gained momentum during the later decade. International Collaborative output had more impact compared to domestic collaboration in terms of citations per paper.

Malti Goel, Vandana Maurya and Pranav N. Desai (2013) [5] have examined this study based on Web of Science publications database in the domain of solar energy R&D in India. Using publication and patent data, analysis from 2000-2009 has been carried out. An attempt has been made to develop introduction R&D output indicators, and data is analyzed in terms of number of the publications, technology-wise distribution, and growth of infrastructure. India is among the five leading countries in term of the number of publications. The Result show that research output in solar energy in India almost double in 2005-2009 as compared to 2000-2004, China, However, stands out in development in Solar R&D by increasing their research output, thin film technology is performing highest both in the world and in India. It is also seen that in India, the publication number has certainly increased, but the per capita publication is much on a lower side. Solar thermal research is yet to pick up. The patents are almost negligible during the period under study. No doubt, a robust R&D infrastructure exists in the country for taking up the challenge of Solar Energy Development. However, research contribution is not keeping pace with the world trends. Only a few institutions are engaged in research. A compelling observation is that despite adequate human resources and infrastructure, India Solar Research and Development is lagging behind.

3. Objective

Main Objective of the study

- To examine the year wise growth of literature during 2008 - 2017.
- To identify the author productivity and bibliographic distribution.

- To analyze country wise distribution.
- To examine the authorship pattern and degree of collaboration.

4. Collection data

From this study, the literature on solar power generation data has been collected from 'Scopus' online database, which is an international indexing and abstracting database using the term "Solar Power Generation" from during the period 2008-2017. The Total number 20,119 publication reflected in the study period at the level in Scopus Database.

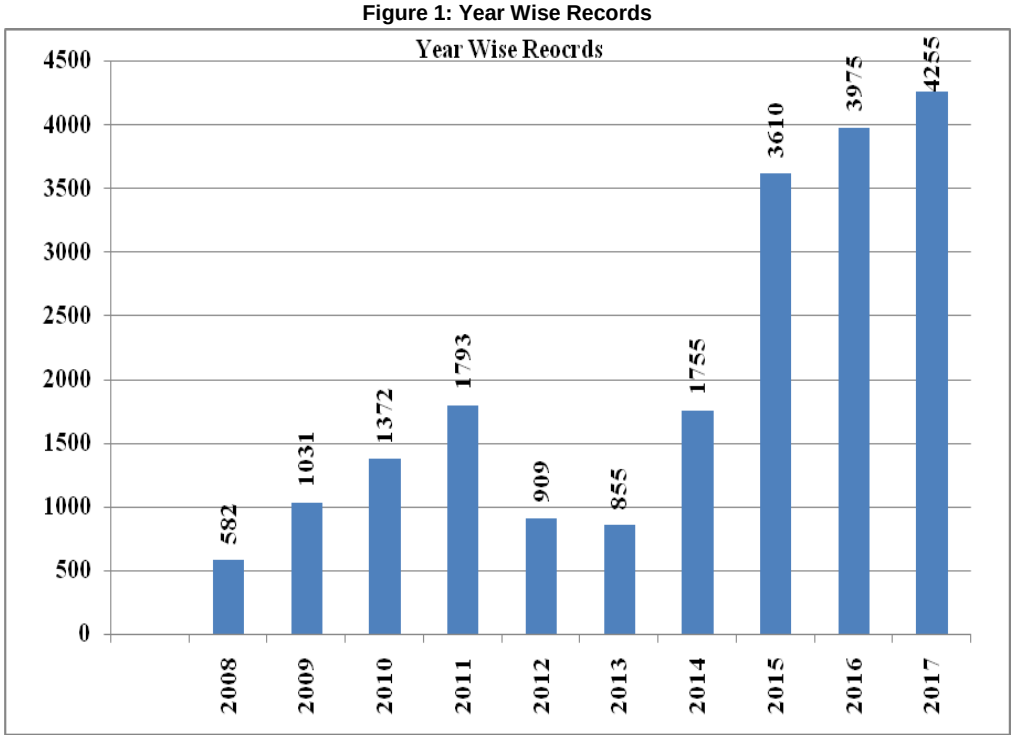
5. Year Wise Growth of Solar Power Generation Literature and Citation

Table 1; figure 1 shows that the year wise distribution of research records and citation are contributed in the field of solar power generation during the period of 2008 – 2017. A total number of records were published 20,119, maximum 4,225 (21.21%) of record published in 2017. Minimum 582 (2.89%) of records published 2008, average 2012 records published per year. The records cited 15,563 and total un cited records 4,556. Total citation of the study period is 3,53,335.

Table 1: Year wise Growth of Solar Power Generation Records, and Citations

Sl. No.	Year	Records	%	Cumulative	Cumulative %	Total records cited	% Total records cited	Total un cited records	% Total uncited records	Total Citations	% Total Citations
1	2008	582	2.89	582	2.89	477	3.06	105	2.30	22616	6.38
2	2009	1031	5.12	1613	8.02	841	5.40	190	4.17	43270	12.21
3	2010	1372	6.82	2985	14.85	1160	7.45	212	4.65	53943	15.22
4	2011	1793	8.91	4778	23.75	1510	9.70	283	6.21	61375	17.32
5	2012	909	4.52	5687	28.27	739	4.75	170	3.73	20804	5.88
6	2013	855	4.25	6542	32.52	687	4.41	168	3.69	16296	4.60
7	2014	1755	8.72	8297	41.24	1292	8.30	463	10.16	22078	6.23
8	2015	3610	17.95	11907	59.18	2931	18.83	679	14.90	57984	16.37
9	2016	3975	19.67	15864	78.85	3102	19.939	873	19.16	36570	10.32
10	2017	4255	21.15	20119	100	2824	18.15	1431	31.41	19399	5.48
Total		**20119**	**100.00**			**15563**	**100**	**4556**	**100**	**354335**	**100**

Figure 1: Year Wise Records



6. Top Ten Author Productivity

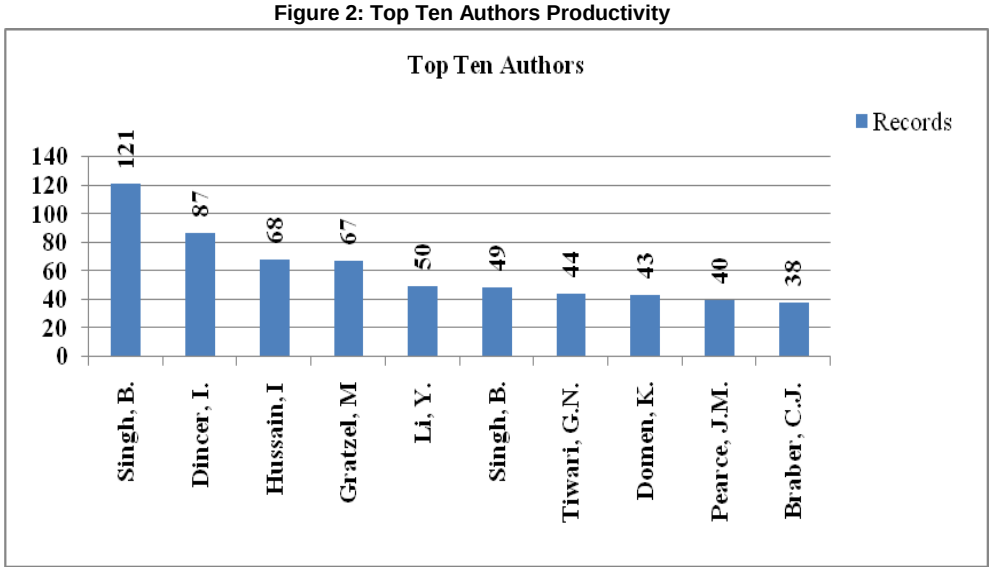
Tables 2, figure 2 shows that top ten author productivity about solar power generation related records from Scopus database during the selected ten years.

Table 2: Top Ten Author Productivity

Sl. No.	Author	Records	% Records	Ranking
1	Singh, B.	121	3.59	1
2	Dincer, I.	87	2.58	2

3	Hussain, I	68	2.01	3
4	Gratzel, M	67	1.99	4
5	Li, Y.	50	1.48	5
6	Singh, B.	49	1.45	6
7	Tiwari, G.N.	44	1.30	7
8	Domen, K.	43	1.27	8
9	Pearce, J.M.	40	1.19	9
10	Braber, C.J.	38	1.13	10
11	Others	2767	82	
Total		**3374**	**100**	

Figure 2: Top Ten Authors Productivity



7. Bibliographic Distribution

Table 3 shows that year wise bibliography distribution of solar power generation from the Scopus database for the period of 2008-2017. Most of the records are published in article 11,476 (57.46%), followed by conference paper 7,348 (36.52%), review 936 (4.66%) and so on. Articles published more than 50 %. Maximum number of records published during the study period articles and conference paper 18,824(93.56%).

Table 3: Bibliographic Distribution of Solar Power Generation Records vs. Year

Sl. No.	Document Type	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Papers	%
1	Article	284	549	715	980	441	401	901	2234	2408	2563	11476	57.04
2	Conference Paper	275	433	582	734	407	386	729	1189	1276	1337	7348	36.52
3	Review	12	37	52	58	41	34	76	129	212	285	936	4.66
4	Book Chapter	6	7	14	13	15	26	29	44	49	23	226	1.12
5	Short Survey	2	3	5	5	1	6	18	6	1	1	48	0.24
6	Book	2	1	2	2	2	1	1	3	3	0	17	0.08
7	Others	1	1	2	1	2	1	1	5	8	46	68	0.34
Total		**582**	**1031**	**1372**	**1793**	**909**	**855**	**1755**	**3610**	**3957**	**4255**	**20119**	**100**

8. Country wise Distribution

Table 4 shows that country wise records of solar power generation related records vs. year from scopus database from 2008 to 2017. The tables reveals that 4,153 (16.41%) records are published the United States with highest in the year 2015 at 732 records, followed by China 3,737 (14.78%) and India rank in 3rd with 1,904 (7.52%) records and highest in the year 2017 at 614 records.

Table 4: Country Wise Distribution

Sl. No.	Country	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Paper	%
1	United States	145	233	366	411	239	229	424	732	718	656	4153	16.41
2	China	70	157	214	349	139	132	270	662	787	957	3737	14.78
3	India	23	47	67	84	54	61	162	331	461	614	1904	7.52
4	Japan	36	69	91	109	47	45	96	153	203	199	1048	4.14
5	Germany	38	83	73	109	56	42	78	197	177	184	1037	4.10

6	United Kingdom	21	45	58	84	36	27	74	164	168	197	874	3.45
7	Italy	15	41	48	61	29	43	65	184	152	154	792	3.13
8	Spain	29	42	51	58	38	29	57	123	143	134	704	2.78
9	Taiwan	18	43	53	83	35	34	51	107	126	92	642	2.53
10	France	26	38	44	46	22	17	52	105	100	97	547	2.16
11	Others	249	443	601	793	384	366	823	1853	2086	2267	9865	39
Total		**670**	**1241**	**1666**	**2187**	**1079**	**1025**	**2152**	**4608**	**5121**	**5551**	**25300**	**100**

9. Authorship Pattern

Table 5 reveal that the maximum number of records was published in three authored 4,245 (21.10%), two authored published 3,484 (17.32%) records, four authored published 3,409 (16.94%) records and eight authored to more than nine authored contribution are below 5 percent. Lowest number of records published nine authored published 564 (2.80%) records. Thus, indicating very clearly the increase trend towards multiple authorship contributions in the field of solar power generation.

Table 5: Authorship Pattern

Sl. No	Authorship Pattern	Records	%
1	Single Author	1276	6.34
2	Two Authors	3484	17.32
3	Three Authors	4245	21.10
4	Four Authors	3409	16.94
5	Five Authors	2527	12.56
6	Six Authors	1727	8.58
7	Seven Authors	1121	5.57
8	Eight Authors	863	4.29
9	Nine Authors	564	2.80
10	More Than 9 Authors	903	4.49
Total		**20119**	**100.00**

10. Degree of Collaboration

The degree of collaboration by year wise has been calculated formula suggested by Subramanyam, K (1983) [10].

Degree of Collaboration C = Nm / Nm + Ns

Where,

Ns = Number of Single Authored Papers,

Nm = Number of Multi authored Papers

Here, Ns = 1276 and Nm = 18843

So, Degree of Collaboration is = 18843/ (1276 + 18843) = 0.94

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Table 6 reveals that the single vs. multi authored paper on solar power generation research productivity. During the year of 2008 to 2017, at the overall level, the single authored records constitute 6.34 percentage of the total publication reported in the study and the remaining 93.66 percentages of the records are contributed by multi-authors. Based on this study, the result of degree of collaboration C = 0.94, i.e., 94 percent of collaborative authors, records published during the study periods

Table 6: Degree of Collaboration

Sl. No.	Year	Total Number of Records	Single Author Records	%	Multi Authors Records	%	Degree of Collaboration C=(Nm / Nm + Ns)
1	2008	582	83	0.41	499	2.48	0.86
2	2009	1031	114	0.57	917	4.56	0.89
3	2010	1372	119	0.59	1253	6.23	0.91
4	2011	1793	150	0.75	1643	8.17	0.92
5	2012	909	72	0.36	837	4.16	0.92
6	2013	855	66	0.33	789	3.92	0.92
7	2014	1755	123	0.61	1632	8.11	0.93
8	2015	3610	176	0.87	3434	17.07	0.95
9	2016	3957	178	0.88	3779	18.78	0.96
10	2017	4255	195	0.97	4060	20.18	0.95
Total		**20119**	**1276**	**6.34**	**18843**	**9.66**	**0.94**

11. Conclusion

The year wise distribution of research records and citation are contributed in the field of solar power generation during the period of 2008-2017; the total number of records were published 20,119, maximum 4,225 (21.12%) of record published in 2017. Minimum 582 (2.89%) of records published in 2008. In bibliography distribution most of records are published in article 11,476 (57.46%), followed by conference paper 7,348 (36.52%), review 936 (4.66%) and so on. Maximum number of records published during the study period articles and conference paper 18,824 (93.56%). In authorship pattern 94 percent of authors were contributed at collaborative produced. It is essential that in the sphere of solar power generation large scale studies are carried out to identify the trends in the collaborative research.

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