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Scientometric Study of Solar Power Generation in India with Special References to Citation Analysis

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Abstract

The citations are a metric study used to evaluate and categorize the documents. The citation analysis is the factual and popular technique used to access, evaluate, compare and to rank the documents based on quality. In Scopus database using the keyword, "solar power generation", reflected in Indian level 1,903 records in during the study period 2008-2017 (10 years). The citation related indicators, such as citation rate, records without citations average citation per paper, top cited publication and their source titles, citation frequency, have presented in the research paper. The above indicators should be able to convey the used records, unused records, highly used records, and source titles.

Keywords: Citation Analysis, Solar Power Generation, Solar Power, Solar Energy, Scientometric Study.

Introduction

When an object is moved against a force, work is done and energy is spent in the process. Energy is the capacity to do work. The word 'energy' is derived from the Greek energeia: en means 'in' and ergon,'work'. Energy occurs in various forms and can be converted from one form to another, but the total energy in any energy conservation process always remains constant; that is, energy can neither be created nor destroyed. Power is the rate at which work is done or energy is used or supplied and may, therefore, be calculated by dividing the work done in the process by the time taken by the process. Solar energy can be harnessed in three ways: (a) by utilizing the heat from sunlight (b) by converting solar energy directly into electrical energy, and (c) by using photosynthetic and biological processes. However before solar energy can be successfully utilized, two major problems need to be solved. Firstly solar energy is highly diffused; that is, it is thinly spread over the earth's surface and so one needs to concentrate it, and secondly, solar energy has to be stored for us during the right or on a very cloudy day. [1].

Review of Literature

B.M. Gupta and S.M. Dhavan (2018) [2] they analysed thin film research in India, publications reflected in Scopus Database during the study period 2000 to 2015 (16 Years) India 14,436 publications with 1,93,849 citations. Contribution of India 5.26 % to the Global Research. Highest publication published in 2014 with 1767 publications. Top 15 Institutions of thin film research 49.67% publications with 53.56% citations. Highest publications published top 3 institutes are Indian Institute of Science, Bangalore, Shivaji University, Kolhapur and Indian Institute of Technology, Delhi. The 11.79% publication with 17.41% citations are the top ten Indian authors involved thin film research.Top seven collaborative countries 66.80% publication share in India.

S.Chandra, & M. Nagarajan (2018) [3], they analysed Tuberculosis research in India, 22,871 publications reflected in Scopus database publication during the study period of 1987 – 2016. They quantitatively analysed the publication year wise, country wise, Language wise distributions, bibliographic form and author pattern. Indian publication is 22,871 (7.41%) with third position of global level research in Tuberculosis. 84 countries were collaborated in Tuberculosis research with Indian authors. Indian research publications of tuberculosis in 12 other languages, other than English. Tuberculosis research output doubles once in five years.

J. Velvizhi, N. Murugesapandian, M. Surulinathi and S.Srinivasaragavan (2011) [4] have analyzed solar energy research in

India reflected in Web of Science during 1999-2011. Publication output of literature by different countries collaboration follows the trend in basic sciences with the USA and South Korea being the major producers with India. The geographical collaboration distributions of the international level show among the 54 countries, India fives priority for research when compared to other countries. The contribution of Indian Institutions and Global Citation Scores, h-index, g-index, and gh-index they analyzed. The maximum number of articles is contributed by multiple authors and that the University wise contributions were the greater limit. The area of Solar Fuels and Material Science multidisciplinary also received maximum attention.

Objective of the Study

1. To find out the Relative Growth Rate (RGR) and Doubling Time (Dt.)
2. The year wise citation rate (CR).
3. Find the records with and without citation.
4. Analyze Average Citation Per Paper (ACCP).
5. Highly Cited records with and their titles.
6. To analyze the citation frequency distribution.

Collection Data

The data source of this study was Scopus (http: // www.scopus.com) multidisciplinary database and keywords obtained in the fields title, keyword and abstract was used to recover the bibliographic records. Scopus database for the period 2008 to 2017 reflected 1,903 records in India contributed in the field of 'solar power generation' over the period of 10 years.

Result and Discussion

Relative Growth Rate and Doubling Time (DT) for Citations

An observe from Table 1, the Relative Growth Rate (RGR) has decreased from 2009 (2.00) to 2012 (0.09), Highest RGR in the year 2009 (2.00). The Doubling Time (Dt) has increased when calculated year wise. The Doubling Time increases from 0.35 in 2009 to 6.93 in 2017.

Table 1
Solar Power Generation Citation vs. Relative Growth Rate and Doubling Time (Dt)

Sl. No.	Year	Citations	Cumulative Citations	W1	W2	RGR	Dt
1	2008	364	364		5.90		
2	2009	2322	2686	5.90	7.90	2.00	0.35
3	2010	2135	4821	7.90	8.48	0.58	1.19
4	2011	3559	8380	8.48	9.03	0.55	1.26
5	2012	774	9154	9.03	9.12	0.09	7.7
6	2013	1285	10439	9.12	9.25	0.13	5.33
7	2014	1371	11810	9.25	9.38	0.13	5.33
8	2015	3145	14955	9.38	9.61	0.23	3.01
9	2016	2959	17914	9.61	9.79	0.18	3.85
10	2017	1745	19659	9.79	9.89	0.10	6.93

Year Wise Records, Citation & Citation Related Indicators

The SCOPUS online database has retrieved 1,903 records, out of it 1,406 (73.88%) received 19,659 citations on solar power generation research in India during 2008-2017. And the 497 (26.12%) has not cited. The Average Citations Per Paper (ACPP) is 20.21.

Citation Rate (CR)

The CR is the indicators used to indicate the quality of the record. During the study period 2008 to 2017, CR average is 0.27. Highest CR in the year 2017 with 0.59, Lowest CR in the year 2010 with 0.10.

$$CR = \frac{Number\ of\ papers\ received\ at\ least\ one\ citation}{Number\ of\ paper\ publis\ hing}$$

Percentage of Not Cited Records (PNC)

Most of the ranking analysis has started from highest lowest; PNC starts from highest will be the starting with negative to positive, so the analysis of PNC has started with lowest to the highest. The highest rank of PNC 40.78 in the year 2017, lowest rank of PNC 89.55 in the year 2010.

$$PNC = \frac{Number\ of\ papers\ publis\ hed - number\ of\ papers\ received\ at\ least\ one\ citation}{Total\ number\ of\ papers\ publis\ hed} * 100$$

Average Citations per Paper (ACCP)

Average citation per paper provides quality of the literature in the group. Highest ACCP in the year 2009 with 49.40 and lowest ACCP in the year 2017 with 2.85. During the study period 2008 to 2017, average ACCP has 20.21. Above average ACCP in the year 2009 (49.40), 2010 (31.87), 2011 (42.37).

$$ACCP = \frac{Citations}{Records}$$

Table 2
Year Wise Records, Citation & Citation Related Indicators

Year	Records	Citations	Cited R	NCR	PNC	CR	ACPP
2008	23	364	21	2	78.26	0.22	15.83
2009	47	2322	43	4	89.36	0.11	49.40
2010	67	2135	64	3	89.55	0.10	31.87
2011	84	3559	81	3	88.09	0.12	42.37
2012	54	774	47	7	79.63	0.20	14.33
2013	61	1285	50	11	68.85	0.31	21.07
2014	162	1371	140	22	69.14	0.31	8.46
2015	331	3145	260	71	65.86	0.34	9.50
2016	461	2959	350	111	61.61	0.38	6.42
2017	613	1745	350	263	40.78	0.59	2.85
Total	**1903**	**19659**	**1406**	**497**	**73.11**	**0.27**	**20.21**
Cited R = Cited Records ; NCR = Not Cited Records ; PNC = Percentage of Not Cited Records ; CR = Citation Rate ; ACCP = Average Citations Per Paper							

Citation Frequency Distribution in Solar Power Generation in India

The year wise number of records received the citation on the interval scale of measurement. The total cited record 1406 (73.88%), highest citation single citations with 263 (11.92%). The zero (0) citation means not cited records, have found 497 (26.12%).

Table 3
Citation Frequency Distribution in Solar Power Generation in India

Citations	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2008-2017	%
>300	0	0	0	3	0	0	0	0	0	0	3	0.16
>250<299	0	1	1	0	0	1	0	0	0	0	3	0.16
>200<249	0	1	1	0	0	0	0	0	0	0	2	0.11
>150<199	0	0	0	0	0	0	0	0	0	0	0	0
>100<149	0	3	2	5	1	3	0	1	0	0	15	0.79
>50<99	2	11	10	11	3	4	7	10	6	0	64	3.36
>25<49	4	16	9	9	4	3	4	26	22	4	101	5.31
>11<24	3	5	16	18	12	12	22	45	55	42	230	12.09
10	0	0	2	0	1	2	1	8	7	7	28	1.47
9	0	0	1	5	1	0	7	10	7	5	36	1.89
8	0	0	4	1	1	1	7	8	16	18	56	2.94
7	2	0	1	3	3	2	3	10	10	16	50	2.63
6	1	0	3	2	0	1	12	14	19	20	72	3.78
5	1	0	3	3	2	0	9	13	19	21	71	3.73
4	0	2	1	3	8	5	10	21	30	24	104	5.47
3	1	2	2	2	3	4	14	25	42	39	134	7.04
2	4	1	4	9	4	4	16	27	51	54	174	9.14
1	3	1	4	7	4	8	28	42	66	100	263	13.82
0	2	4	3	3	7	11	22	71	111	263	497	26.12
Total	**23**	**47**	**67**	**84**	**54**	**61**	**162**	**331**	**461**	**613**	**1903**	**100**

The 263 (11.92%) records have received one citation each; during the study period, the highest number of citation has received. The 174 (9.14%) records received two citations; followed 134 (7.04%) records received three citations. The 104 (5.47%) records received four citations; followed by the five citations with 71(3.73%) records. The 72 (3.78%) records received six citations, followed by the seven citations with 50 (2.63%) records. The 56 (2.94%) records received eight citations, followed by the nine citations with 36 (1.89%) records. The 28 (1.47%) records received ten citations, followed by 230 (12.09%) records received the citation between the ranges of 11-24.

The 101 (5.31%) records received the citation between the ranges of 25-49, followed by 64 (3.36%) records received the citation between the range of 50-99. The 15 (0.79%) records received the citation between the ranges of 100-149. Followed by the next four categories of 150-199 citations, 200-249 citations, 250-299 citations, 300 and above citations, and for the above four categories, the total 8 records found them. The top most categories for receiving one citation with 13.82 percent; followed by the categories of the record which citation received the citation between ranges > 11< 24 counts with 12.09 percents. It has observed that about 56 percent of the cited records receives the citation range of 1-6. About 34% cited record received citation range 7-49. Rest of 10% records received the citation range 50 > 300 citations.

Highly Cited Publications

The number of citations of a publication indicates the importance of the publication in the

academic community. The most cited 23 publications have listed in table with other relevance information. It contains the name of the author, year of publications, the source title, volume, and issues number and the citations.

Table 4
List of Top Cited Publications in Solar Power Generation in India Received >100 Citations

Sl.No.	Authors	Year	Source Title	Vol.	Issue	Cited
1	Panwar, .L.,+(2)	2011	Renewable and Sustainable Energy Reviews	15	3	635
2	Parida, B., +(2)	2011	Renewable and Sustainable Energy Reviews	15	3	543
3	Miyatake, M.+(4)	2011	IEEE Transactions on Aerospace and Electronic Systems	47	1	300
4	Mani, M., +(1)	2010	Renewable and Sustainable Energy Reviews	14	9	295
5	Singh, G.K.	2013	Energy	53		267
6	Jain, I.P.	2009	International Journal of Hydrogen Energy	34	17	262
7	Lonsdale, .J+(47)	2009	Proceedings of the IEEE	97	8	240
8	Lalitha, K.,+(5)	2010	Journal of Physical Chemistry C	114	50	214
9	Abbasi, T.,+(1)	2011	Renewable and Sustainable Energy Reviews	15	6	149
10	Dubey, S.,+(2)	2009	Applied Energy	86	5	135
11	Agrawal, B.+(1)	2010	Applied Energy	87	2	133
12	Bhatnagar, P.,+(1)	2013	Renewable and Sustainable Energy Reviews	23		132
13	Khare, A.,+(1)	2013	Applied Soft Computing Journal	13	5	132
14	Kumar, S.,+(1)	2009	Applied Energy	86	10	121
15	Suganthi,L., +(2)	2015	Renewable and Sustainable Energy Reviews	48		118
16	Dubey, S.,+(1)	2009	Solar Energy	83	9	114
17	Kundu, P.,+(3)	2011	Journal of Materials Chemistry	21	12	113
18	Dutta, M.,+(3)	2012	Journal of Physical Chemistry C	116	38	109
19	Roy Chowdhury, S., +(1)	2010	Solar Energy Materials and Solar Cells	94	9	109
20	Abu-Rub, H.,+(5)	2013	IEEE Transactions on Sustainable Energy	4	1	108
21	Agrawal, S.,+(1)	2011	Solar Energy	85	2	107
22	Rai, A.K. +(3)	2011	Solar Energy Materials and Solar Cells	95	2	107
23	Kumar, P.,+(4)	2011	International Journal of Hydrogen Energy	36	4	103
+( ) indicates no. of additional authors						

During the study period table 4,Panwar, N.L., Kaushik, S.C. and Kothari, S. have jointly received the highest number of citation (635) for their publication 'Role of renewable energy sources in environmental protection: A review published in Renewable and Sustainable Energy Reviews vol. 15 (3), 2011. Second highest cited record (543), A review of solar photovoltaic technologies by Parida, B., Iniyan, S. and Goic, R. published in Renewable and Sustainable Energy Reviews vol.15(3), 2011. Miyatake, M along with 4 co-authors published the title Impact of dust on solar photovoltaic (PV) performance: Research status, challenges, and recommendations published in IEEE Transactions on Aerospace and Electronic Systems vol. 47(1), 2011 ranked at third position. Followed by Mani, M. and Pillai, R. with 295 citations for their record, Impact of dust on solar photovoltaic (PV) performance: Research status, challenges, and recommendations, published in Renewable and Sustainable Energy Reviews Vol. 14(9), 2010.Singh, G.K. published Solar power generation by PV (photovoltaic) technology: A review published in the journal Energy, Vol.53, 2013, ranking at fifth position with 267 citations.

The International Journal of Hydrogen Energy, Vol 34(17), 2009 has contained an article, Hydrogen the fuel for the 21st century by Singh, G.K. received 262 citations, ranked at the sixth position. Followed by The Murchison widefield array: Design overview by Lonsdale, C.J with 47 co-authors appeared in Proceedings of the IEEE, Vol. 97(8), and 2009 holding the seventh rank with 240 citations. The Lalitha, K., and five others have ranked at eight position with 214 citations for their article, highly stabilized and finely dispersed Cu2O/TiO2: A promising visible sensitive photocatalyst for continuous production of hydrogen from glycerol: water mixtures in Journal of Physical Chemistry C Vol. 114 (50), 2010, and so on. Among the 23 top-cited publications six have published by Renewable and Sustainable Energy Reviews (highest cited publications has observed in the above journal), followed by Applied Energy with three publications. International Journal of Hydrogen Energy, Solar Energy, Journal of Physical Chemistry C and Solar Energy Materials and Solar Cells with two publication each.

From the Bradfords' Law of Scattering twelve source titles have identified as core journals in one

hand and highly cited 23 publications on other. It also observed that only two source titles of core journals have included in highly cited publications as (1) Renewable and Energy Reviews (appeared six times) and (2) Applied Energy (appeared three times).

Findings

1. Total 1903 records, cited records 1406 (73.89%) with 19,659 citations.
2. Not Cited Records 497 (26.12%) out of total 1903 records.
3. CR average is 0.27.
4. Highest CR in the year 2017 with 0.59,
5. Lowest CR in the year 2010 with 0.10.
6. The highest PNC in the year 2017 with 40.78.
7. Lowest PNC in the year 2010 with 89.55.
8. The Average Citation Per Paper (ACCP) has 20.21 %.
9. Highest ACCP in the year 2009 with 49.40%.
10. Lowest ACCP in the year 2017 with 2.85 %.
11. 56 % of the cited records receive the citation range of 1 - 6.
12. 34 % of the records received citation range 7 - 49.
13. 10 % of the records received citation range 50 > 300.

Conclusion

The funding agencies must come forward for developing the research aspects in Solar Power Generation. In India, the Ministry of New and Renewable Energy (MNRE) has established Solar Power Generation research implementing in various places in India, because in India, Three hundred days (300) clear and sunny days per year and Solar Power is Environmental Friendly.

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