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Solar Power Generation Research in India: A Scientometric Assessment of Indian Publications Output During 2008 - 2017

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Abstract – This study analysed the Indian Solar Power Generation research record output during 2008 – 2017 is using for different scientometric indicators. Data retrieved from SCOPUS international multidisciplinary online database using the search keywords Indian and Solar Power Generation. During the Study Period, a total number of 20,119 records have been identified. Out of which, 1,903 records are contributed in India. From the study analyzed the statistical tools such as the growth of publication in Globe and India, the percentage of sharing in Indian authors' record, the ranking of top 20 institution and journals contributions and scientometric techniques such as AI and PEI. Analysis of document wise distribution and authorship pattern.

Keywords – Solar Power Generation, Solar Power, Solar Energy, Solar Energy in India, Sientometric Study

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INTRODUCTION

In the day of energy crisis where fossil fuel becoming scared day by due to limited stock. We shall have to depend on renewable energy more and more in the future. There are several types of renewable energy, but solar energy remains as one of the principal renewable energies which can be utilized very effectively and perhaps this is one of the most efficient types of energy provides we can utilize effectively and provide we can store it for use any time we are in need. With such national and international priority, it is with necessary to bring out research on solar energy so that more thoughts can be circulated for more effective use to enable us to have the society of better tomorrow.

In India different technical institutes' research on solar energy was conducted, and the use of solar energy in different operations been encouraged. In order to the popularised solar energy system, Government is also thinking about providing the subsidy for people, to use the solar cookers, etc. And to monitor the solar energy activities department of non-renewable energy sources has been created are also doing different research activities throughout the country. Perhaps a day will come when the ray from the sun may become the principal source of energy for our day to day use (Ghosh, 1991).

REVIEW OF RESEARCH

S.H. Bhimappa and K.R.Mulla [2] analyzed Bio-Fuel Literature in India reflected from Web of Science (WoS) for the period of 1989 to 2014 (25 Years) with 757 publications. The National Policy of Bio-Fuel has facilitated to most select development and utilization of indigenous biomass feedstock for production of biofuels in India are derived from renewable biomass resources and, to supplement conventional energy sources in meeting the fast increasing requirements for transportation fuels associated with high economic growth, as well as in meeting the energy needs of India's vast rural population. Determine the core journals in the field identify the prolific authors in the field, Analyze the most productive institutions and funding agencies. From 2012 onwards Government Funded Institutions were more active in research on biofuel and its related discipline.

C. Ranganathan, [3] analyzed Green Energy Research in India reflected from the web of science (WoS) for the period 1999 to 2013 (15 years)with 1,105 publications. The authorship trend

shows that 94.5% of them or published under the joint author of publications in green energy research output. It is observed that author productivity is not in agreement with Lotka's Law. A comparison of Indian output in relation to the world output may help in understanding the contribution to a better angle. Through the records available in the Web of Science database reveals a small number, and it is important that the impact of publications on green energy may be visible.

R. Kanagarasu [4] analyzed the wind energy research in India reflected in Web of Science (WoS) for the period 1993-2012. Totally 6,224 publications from India, with 2,639 proceeding papers, 2,799 articles, and 339 reviews, with 3,154 institutions participated publications. About 9.4% of publications are contributed by Indian Institute of Technology, Kanpur followed by Bhabha Atomic Research Centre, Bombay (7.27%). Indian researchers have appeared in journals with impact factors between 0.20 and 4.14. About 23.23% of authors contributed single articles. The growth rate of publications varied from 0.50 to 14.7% per year. The annual growth rate was highest in the year 2012 at 14.7%. The study reveals that the output of wind energy research in India has gradually increased over the year.

MAIN OBJECTIVE OF THE STUDY

- to analyze the growth of solar power generation research Publications in Globe and India
- to identify the Activity Index
- to analyses Document Type
- to analyze Authorship Pattern
- to identify the Ranking of top 20 Institutions in India from Solar Power Generation Publication
- To analyze Top 20 Most Productive Journals in India's Solar Power Generation
- to find Relative Research Effort

Collection Data

From this study, the Indian authors' research on Solar Power Generation research publications has been downloaded from 'SCOPUS', multidisciplinary online database during 10 years from 2008 to 2017. For this study, using the search term TITLE-ABS-KEY "Solar Power Generation"AND AFFILCOUNTRY"india"AND PUBYEAR>2007 AND PUBYEAR < 2018". The total no of 20,119 records has been reflected in the global level. Out of which, 1903 records are contributed in India. The research records data have been classified by using Microsoft Excel for the purpose of analysis.

Limitations

- This study is confined to the SCOPUS database only.
- Indian authors research publications in solar power generation data have been used for the study from 2008-2017.

RESULT AND DISCUSSION

Year Wise Global Growth of Publication and India

The table 1 shows that, the Global wise growth of publications on solar power generation and the share of India. The publication position of global is highest in the year 2017 with a record count of 4255 (21.15%), lowest in the year was 2008 with 582(2.89 %), and the average publications were 2012(10%). India shared with a record count of 1903 (9.46%), out of which the highest number of publications was in the year 2017. The records count of 613(32.21%) with an annual share of 14.41%, the lowest number of publications was in the year 2008, with 23(1.21%) research publications. The average publication share of India was 190.3(10%). The year 2017 was most prolific for the highest number of publications for Global Wise 4255(21.45%) and India 613 (32.21%).

Activity Index

The comparison of India's contributions with the global contributions was carried out using the Relative Activity Index (AI), first suggested by Frame. The relative index whether a unit is a more or less activity in India than the rest of the world.

$AI = (n_{ij} / n_{io}) / (n_{oj} / n_{oo}) \times 100$

Where,

n_{ij} = Indian output of paper in a field ; n_{io} = total India output in all fields

n_{oj} = World output of paper in a particular field ; n_{oo} = total World output in all fields

AI = 100 indicates that the country research effort is the world average; AI >100 reflects higher activity than the world average; AI < 100 reflects lower than the average effort dedicated to the field under study. From the table 1 indicate that India's research effort is increased the world average year by year. The average AI for India was 79.88 during 2008 – 2017.

Table 1: Growth of publications in Globe and India

Sl. No.	Year	Globe Records	%	Indian Records	%	Indian Share	AI
1	2008	582	2.89	23	1.21	0.11	41.78
2	2009	1031	5.12	47	2.47	0.23	48.196
3	2010	1372	6.81	67	3.52	0.33	51.63
4	2011	1793	8.91	84	4.41	0.42	49.53
5	2012	909	4.51	54	2.84	0.27	62.81
6	2013	855	4.24	61	3.20	0.30	75.43
7	2014	1755	8.72	162	8.51	0.81	97.60
8	2015	3610	17.94	331	17.40	1.65	96.94
9	2016	3975	19.75	461	24.22	2.29	122.61
10	2017	4255	21.45	613	32.21	3.05	152.31
Total		**20119**	**100**	**1903**	**100.00**	**9.46**	**100**
Average		**2012**	**10**			**18.92**	**79.88**

Document Type

Document type for the Indian authors' publications is shown in table 2. During the study period a maximum of 926 (48.66%) records is contributed in Conference Paper followed by articles are 862 (45.30 %), review 91(4.78%), and remaining 1.30 % are contributed in Book Chapter, Letter, Book, Editorial, Article in Press, Note, and Short Survey.

Table 2: Document type of solar power generation in India

Sl. No.	Document Type	Publications	%	Cum.	Cum.%
1	Conference Paper	926	48.66	926	48.66
2	Article	862	45.30	1788	93.96
3	Review	91	4.78	1879	98.74
4	Book Chapter	17	0.89	1896	99.63
5	Letter	2	0.11	1898	99.74
6	Book	1	0.05	1899	99.79
7	Editorial	1	0.05	1900	99.84
8	Article in Press	1	0.05	1901	99.89
9	Note	1	0.05	1902	99.95
10	Short Survey	1	0.05	1903	100.00
Total		**1903**	**100.00**		

Authorship Pattern

During the study period table, 3 shows that the authorship pattern of India author's solar power generation reaches publications. From the study, the highest no of 403(21.18 %) publications are contributed in three authors, followed by 358 (18.81 %) publications are contributed in two authors, 261 (13.72 %) publications are five authors, and so on. From the Study, the highest no of twenty authors contributed in one paper, followed by seventeen authors contributed in one paper and so on.

Table 3: Authorship Pattern in solar power generation in India

Sl. No.	No of Authorship	No of Publications	%	No of Authors	%
1	1	37	1.94	37	0.41
2	2	358	18.81	716	7.87
3	3	403	21.18	1209	13.29
4	4	212	11.14	848	9.32
5	5	261	13.72	1305	14.34
6	6	249	13.08	1494	16.42
7	7	62	3.26	434	4.77
8	8	115	6.04	920	10.11
9	9	82	4.31	738	8.11
10	10	59	3.10	590	6.48
11	11	24	1.26	264	2.90
12	12	17	0.89	204	2.24
13	13	10	0.53	130	1.43
14	14	9	0.47	126	1.38
15	15	1	0.05	15	0.16
16	16	2	0.11	32	0.35
17	17	1	0.05	17	0.19
18	18	0	0	0	0
19	19	0	0	0	0
20	20	1	0.05	20	0.22
Total		**1903**	**100.00**	**9099**	**100**

Ranking of top 20 Institutions in India from Solar Power Generation Publication

Table 4 shows that top 20 Institutions are contributed 849 publications with his rank. Top 20 Institutions Indian Institute of Technology, Delhi got the first rank with 269 (31.68%) publications, followed by Indian Institute of Technology, Bombay with 74(8.72 %) publications, and third ranks Anna University, Chennai with 50 (5.89 %) publications, and so on.

Table 4: Ranking of top 20 Institutions in India

Sl. No.	Institution and place	State	Pub.	%	Rank
1	Indian Institute of Technology, Delhi	New Delhi	269	31.68	1
2	Indian Institute of Technology, Bombay	Maharastra	74	8.72	2
3	Anna University, Chennai	Tamil Nadu	50	5.89	3
4	Vellore Institute of Technology, Vellore	Tamil Nadu	49	5.77	4
5	Indian Institute of Science, Bangalore	Kharnataka	34	4.00	5
6	Indian Institute of Technology, Roorkee	Uttarakhand	34	4.00	5
7	Indian Institute of Technology, Kanpur	Uthra Pradesh	32	3.77	6
8	Indian Institute of Engineering Science and Technology, Shibpur	West Bengal	29	3.42	7
9	National Institute of Technology, Tiruchi	Tamil Nadui	28	3.30	8
10	Council of Scientific and Industrial Research India, New Delhi	New Delhi	28	3.30	8
11	Indian Institute of Technology, Madras	Tamil Nadu	27	3.18	9
12	Maulana Azad National Institute of Technology, Bhopal	Madha Pradesh	26	3.06	10
13	SRM Institute of Science and Technology, Chennai	Tamil Nadu	23	2.71	11
14	Indian Institute of Technology, Kharagpur	West Bengal	22	2.59	12
15	Jadavpur University, Kolkata	West Bengal	22	2.59	12
16	Jai Narain Vyas University, Jodhpur	Rajasthan	21	2.47	13
17	Jamia Millia Islamia, New Delhi	New Delhi	21	2.47	13
18	Delhi Technological University, New Delhi	New Delhi	20	2.36	14
19	Kalinga Institute of Industrial Technology, Bhuva neswar	Odisha	20	2.36	14
20	Sri Sivasubramaniya Nadar College of Engineering, Chennai	Tamil Nadu	20	2.36	14
Total			**849**	**100.00**	

Top 20 Most Productive Journals in India's Solar Power Generation Research Publication

Table 5 shows that a total number of 562 records are contribute to the top 20 journals. Renewable and Sustainable Energy Review contributed to 68

(12.10%) records with 1st rank. Followed by Solar Energy contributed 67(11.92%) records with 2nd rank, India International Conference on Power Electronics licpe contributed 40 (7.11 %) records with 3rd rank.

Table 5: Top 20 Most Productivity journal in India

Sl. No.	Journals	No. of Publications	%	Rank
1	Renewable and Sustainable Energy Review	68	12.10	1
2	Solar Energy	67	11.92	2
3	India International Conference on Power Electronics licpe	40	7.11	3
4	2016 IEEE 7th Power India International Conference ppiicon 2016	39	6.94	4
5	1st IEEE International conference on Power Electronics Intelligent Control and Energy system Icpeices 2016	36	6.41	5
6	International Journal of Hydrogen Energy	32	5.70	6
7	Solar Energy materials and Solar Cells	29	5.16	7
8	Rsc Advances	27	4.80	8
9	12th IEEE International Conference on Power Electronics Drives and Energy systems Pedes 2016	26	4.63	9
10	Renewable Energy	22	3.91	10
11	Energy	21	3.74	11
12	Energy Procedia	21	3.74	11
13	IEEE International conference on Power Electronics Drives and Energy Systems Pedes 2016	21	3.74	11
14	Energy Conversion and Management	20	3.56	12
15	2016 IEEE 6th International Conference on Power System icps 2016	17	3.02	13
16	Journal of Renewable and Sustainable Energy	17	3.02	13
17	Let Renewable Power Generations	16	2.85	14
18	ACS Applied Materials and Interfaces	15	2.70	15
19	2016 International Conference on Energy Efficient Technologies for Sustainability Iceets 2016	14	2.49	16
20	2016 National Power Systems Conference Npsc 2016	14	2.49	16
Total		**562**		

Relative Research Effort

The relative research effort was being measured by the Publication Efficiency Index (PEI), and it is based on the references appended to the research articles by the authors. PEI calculated by the formula used by Guan. j., & Ma, M. (2007) (Gupta & Dhawan, 2018)

$$PEI = \frac{TNCi}{TNCt}$$

$$TNP_i / TNP_t$$

Where

TNCi = total number of references in a year

TNCt = total number of references for all the years

TNPi = total number of papers in a year

TNPt = total number of papers for all the years

If the value of PEI is greater than 1for a country, it indicates that the impact of publications is more, and the research effort is highly devoted to that particular country. Table described the year wise Publication Efficiency Index (PEI). PEI has been calculated from 2008-2017at 1903 publications. The years 2013, show a higher impact of publications. Further, it is found that the average reference per paper is 24.51.

Table 6: Relative Research Effort

Year	Publications	Reference	ARPP	PEI
2008	23	408	17.74	0.69
2009	47	951	20.23	0.78
2010	67	1642	24.51	0.95
2011	84	2117	25.20	0.97
2012	54	1292	23.93	0.92
2013	61	1857	30.44	1.18
2014	162	3602	22.23	0.86
2015	331	9454	28.56	1.10
2016	461	12421	26.94	1.04
2017	613	15499	25.28	0.98
2008-2012	275	6410	22.33	0.86
2013-2017	1628	42883	26.69	1.03
2008-2014	1903	49243	24.51	Avg = 0.95
ARPP = Average Reference Per Paper ; PEI = Publication Efficiency Index				

FINDING AND CONCLUSIONS

- During the Study Period of solar power generation, a total number of 20,199 records are published in the global level. Out of 1903 (9.46%), records are contributed to India. From the study, in the global level, the highest number of 4,255 (21.15%) records in the year 2017, in India 613 (32.21%) in the year 2017 with the annual share 14.41 %.
- During the study period, Indian solar power generation research activates index average is 79.88.
- Indian authors contributed solar power generation in Document Type maximum of 926 (48.66%) records are contributed in Conference Paper.
- Authorship Pattern of the study period, the highest number of 403 (21.18 %) records is contributed in three authors.
- Solar Power Generation in India first rank institutions Indian Institute of Technology, Delhi with 269 (31.68%) records.
- During the study period Indian solar power generation research, 1st rank journal name was Renewable and Sustainable Energy Review with 68 (12.10%) records.
- Average PEI is 0.95 in the study period of solar power generation research in India

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