India's Contribution on Renewable Energy Research Output: A Scientometric Study

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Abstract

Analyses the growth and development of renewable energy research productivity in India in terms of publication output as reflected in Web of Science Database for the period of 2001-2013. It includes 652 publications from India, contains 432 articles, 186 reviews, 25 proceeding papers, 6 letters and Meeting abstract, Book review, Book chapter have 1 record from 540 Institutions. About 17.79 percent of publications is contributed by Indian Institute of Technology, Chennai followed by National Institute of technology, Calicut (5.67%). All the papers published by Indian researchers have appeared in journals with impact factors between 0.358 and 6.626. The growth rate of publications varied from 0.17 to 0.82 percent. The annual growth rate was highest in the year 2002 at 0.82 %. The study reveals that the output of renewable energy research in India has gradually increased over the years

Keywords

Renewable energy; Scientometric study; Impact factor; h-index; Relative growth rate

Electronic access

The journal is available at www.jalis.in

Journal of Advances in Library and Information Science
ISSN: 2277-2219 Vol. 4. No.4. 2015. pp. 311-316

INTRODUCTION

Scientometrics as a technique has extensive applications in identifying the research trends in a subject, trends in an authorship and collaboration in research, core periodicals, obsolescence and dispersion of scientific literature useful in estimating the comprehensiveness of secondary periodicals, studying the author productivity and impact of research, distribution of scientific publications by Research organisation, citation studies and so on. Further, Scientometrics could be used in the identification of emerging research areas. The renewable energy sources, derived principally from the enormous power of the sun's radiation, are at once the most ancient and the most modern forms of energy used by humanity. Renewable energy is energy generated from natural resources—such as sunlight, wind, rain, tides and geothermal heat—which are renewable (naturally replenished). Renewable energy technologies range from solar power, wind power, hydroelectricity/micro hydro, biomass and biofuels for transportation. Technologies for harnessing the powers of sun, firewood, water and wind continued to improves right up to the early years to the industrial revolution. This paper aims to map renewable energy research in India over a period of 13 years (2001–2013) as reflected through web of science. The study is intended to examine, the volume of work published in the renewable energy, the journals that publish the research output on renewable energy and their standing (as reflected by their impact factors) and the institutions which actively publish in this field.

OBJECTIVES

1. To study the year-wise growth of publications
2. To study the document type-wise contributions
3. To study the relative growth rate and doubling time
4. To study the time series analysis
5. To study the Authors, the Organisations and the Funding agencies contribution ; and
6. To study the highly cited papers

Table 1: Year wise publication on Renewable Energy

S. No	Years	Records	Percent
1	2001	11	1.687
2	2002	14	2.147
3	2003	10	1.534
4	2004	22	3.374
5	2005	11	1.687

6	2006	16	2.454
7	2007	39	5.982
8	2008	51	7.822
9	2009	63	9.663
10	2010	78	11.963
11	2011	85	13.037
12	2012	107	16.411
13	2013	145	22.239
	Total	**652**	**100**

The selected sample period taken for this analysis of renewable energy research productivity is from 2001 to 2013, it is totally Thirteen (13) years. Total records gathered from the web of Science database is 652, from that records the above table has revealed that the year wise exploration, it shows the 1.68 percent of records were at the starting year of 2001 and it risen 22.23 percent of records at the ending year of 2013. This results shows that more than 19 times increased publication of between the Thirteen years.

Among the selected periods, the year of 2013 having highest number of publications of 145 (22.23 %) and its stood be a first rank position of publications in renewable energy research. The year of 2012 having the 107 (16.41 %) of publications and its stood be in second rank position of selected research output and the year of 2011 having the 85 (13.03%) of publications and its stood be in third rank position of selected research output. The remaining years were contributed below 50 percent of records (315) of publications in renewable energy.

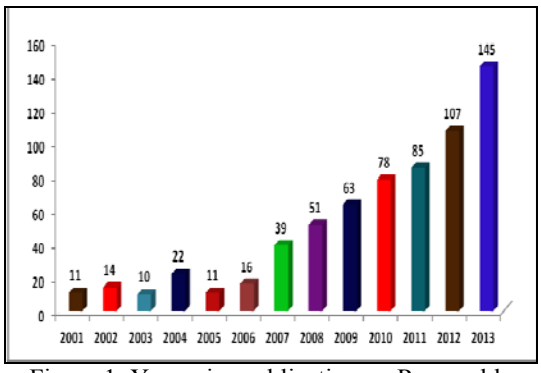


Figure 1: Year wise publication on Renewable Energy

Table 2: Document Types of Renewable Energy

S. No	Documents	Records	Percent
1	Articles	432	66.257
2	Reviews	186	28.528
3	Proceeding Papers	25	3.836
4	Letters	6	0.920
5	Meeting Abstract	1	0.153
6	Book Review	1	0.153
7	Book Chapter	1	0.153
	Total	**652**	**100**

The analysis to preference channels of communication by the productive of Indian scientists for publication output in renewable energy is an essential aspect of bibliometric and scientometric analysis. Scientists have communicated their publications through a variety of communications channels. Such that, Articles (66.25%), Reviews (28.52%), Proceeding Papers(3.83%), Letters(0.92%), Meeting abstracts (0.15%), book reviews (0.15%) and Book chapters(0.15%).

Table 3: Relative Growth Rate and Doubling Time of Renewable Energy Research Output

Year	R. o/p	Cum. o/p	$log_e 1^p$	$log_e 2^p$	Rt(P)	Dt(P)
2001	11	11	-	2.397	-	-
2002	14	25	2.397	3.218	0.821	1.18
2003	10	35	3.218	3.555	0.337	0.48
2004	22	57	3.555	4.043	0.488	0.70
2005	11	68	4.043	4.219	0.176	0.25
2006	16	84	4.219	4.394	0.175	0.25
2007	39	123	4.394	4.812	0.418	0.60
2008	51	174	4.812	5.159	0.347	0.50
2009	63	237	5.159	5.476	0.317	0.45
2010	78	315	5.476	5.752	0.276	0.39
2011	85	400	5.752	5.991	0.239	0.34
2012	107	507	5.991	6.228	0.237	0.34
2013	145	652	6.228	6.480	0.252	0.36
Total	**652**				**4.083** **(0.31)**	**5.84 (0.45)**

This analysis aims to identify the trends and growth of prospects in the present research. It is observed that its relative growth rates have decreased gradually from 0.821 at 2002 to 0.252 in the year of 2013. The whole study period sample mean relative growth rate of 0.31 and the doubling time of renewable energy research output has decreased from 1.18 in 2002 to 0.36 in 2013. The whole study period sample mean doubling time values is 0.45 years. This id carried that there is a general progressive increase in the number of publications of research output on school education. However, its relative growth rate has

shown a booming trend, which means the rate of increase is low in terms of proportion, and this has been highlighted by doubling time for publications, which is more than the relative growth rate.

Table 4 : Time Series Analysis on Renewable Energy

S. No	Years	Records(Y)	X	X^2	XY
1	2001	11	-6	36	-66
2	2002	14	-5	25	-60
3	2003	10	-4	16	-40
4	2004	22	-3	9	-66
5	2005	11	-2	4	-22
6	2006	16	-1	1	-16
7	2007	39	0	0	0
8	2008	51	1	1	51
9	2009	63	2	4	126
10	2010	78	3	9	234
11	2011	85	4	16	340
12	2012	107	5	25	535
13	2013	145	6	36	870
	Total	**652**		**182**	**1886**

Straight line equation is applied to arrive at projections for future growth under Time Series analysis.

Straight Line equation $Y_c = a + bX$

Since $\sum x = 0$

$a = \sum Y/N = 66512/25 = 2660.18$;

$b = \sum XY/\sum x^2 = 321757/1300 = 247.58$

$a = \sum Y/N = 652/13 = 50.15$;

$b = \sum XY/\sum x^2 = 1886/182 = 10.36$

Estimated literature in **2018** is When X = 2018-2001 = 17

= 50.15+ 10.36*17 **= 226.27**

Estimated literature in **2023** is When X = 2023-2001 = 22

=50.15+10.36*22 = **278.07**

On the application of the formula of Time Series Analysis and subsequently, from the results obtained separately for the years 2018 and 2023, it is found that the future trend of growth in Renewable Energy research output may take an increasing trend during the years to come. The inference is that there is a positive growth at the Global level in research literature output on Renewable Energy.

Table 5: Authors Contribution on Renewable Energy (1373)

S. No	Name	Records	%	ACPI	H index
1	Kumar	16	2.454	12	7
2	Saini RP	15	2.301	11.60	8
3	Varun	10	1.534	12.40	6
4	Singh GK	10	1.534	14	6
5	Jain S	10	1.534	20.50	5
6	Iniyan S	10	1.534	39.70	7
7	Sharma MP	9	1.380	23.11	6
8	Nagarajan G	9	1.380	17.00	7
9	Kandpal TC	9	1.380	17.67	7
10	Ramachandra TV	8	1.227	22.25	5

There are 1,373 authors were contributed 652 records on renewable energy research in India. The above table reveals that first 10 prolific authors of renewable energy research belongs to their highest productivity. In the present study, the authors are ranked on the basis of their maximum number of papers published.

The author of 'Kumar' has published 16 articles and it occupies the first rank in renewable energy research output followed by ' Saini RP (15) and Varun (10) occupied second and third rank respectively. Six authors only have contributed ten and more articles remaining authors have below 10 articles.

Table 6: Organization contribution on Renewable Energy(540)

S. No	Name	Records	Percentage of 652
1	IIT, Delhi	116	17.79
2	NIT, Calicut	37	5.67
3	Anna University, Chennai	34	5.21
4	Indian Inst. of Science, Bangalore	23	3.52
5	Indian Inst. Technology, Delhi	16	2.45
6	Indian Inst Chemical Technology	12	1.84
7	CSIR, Newdelhi	11	1.68
8	Maulana Azad Nat. Inst Tech.	8	1.22
9	Indian Inst. Management	8	1.22
10	Banaras Hindu University	8	1.22

The above table indicates that institution wise research productivity in the field of renewable energy

research output. Totally 540 institutions from India were brought out the research output of the field of whole sample data. The institution of "IIT, Chennai" has the highest publication in school education 116 (17.79 %) productivity of during the study period. "NIT, Calicut" which resulted in more number of publications 37 (5.67 %) and stood in second rank among 540 various institutions. "Anna University, Chennai" has brought out the publications 34 (5.21 %) third ranks in the selected field. The first seven organizations contributed more than ten records and the remaining below ten.

Table 7: Funding Agencies Contribution on Renewable Energy (689)

S. No	Name	Records	Percent of 652
1	Council Of Scientific And Industrial Research, (CSIR) Newdelhi	21	3.22
2	Dept. of Science and Tech. New Delhi	9	1.38
3	Ministry of New and Renewable Energy, Govt. of India.	8	1.22
4	Department of Biotechnology, Govt. of India	8	1.22
5	University Grants Commission, government of India	6	0.92
6	Indian Institute of Technology, Delhi	4	0.61
7	Maharana Pratap Univ. of Agri. & Tech. Rajasthan, India	2	0.30
8	Intelligent Energy Europe Programme	2	0.30
9	Ministry of Human Resource Development, Govt. of India	2	0.30
10	Indian Institute of Science, Bangalore	2	0.30

It is found from the analysis that there are large numbers of funding agencies (689) were acknowledged by the research publications on renewable energy across the Nation. It is revealed that Council Of Scientific And Industrial Research, (CSIR) Newdelhi has the 21 publications (3.22 %) output from this sponsored research, while Department of Science and Technology, New Delhi (1.38 %) is at the second position that has sponsored the research for 9 publications, Ministry of New and Renewable Energy, Govt. of India and Department of Biotechnology, Govt. of India (8) is at the third position among sponsoring agencies. Among the 689 institutions, top 10 (1.53%) familiar institutions have contributed 9.77 percentage research output.

Table 8: Renewable Energy Research output on Indian Journals (203)

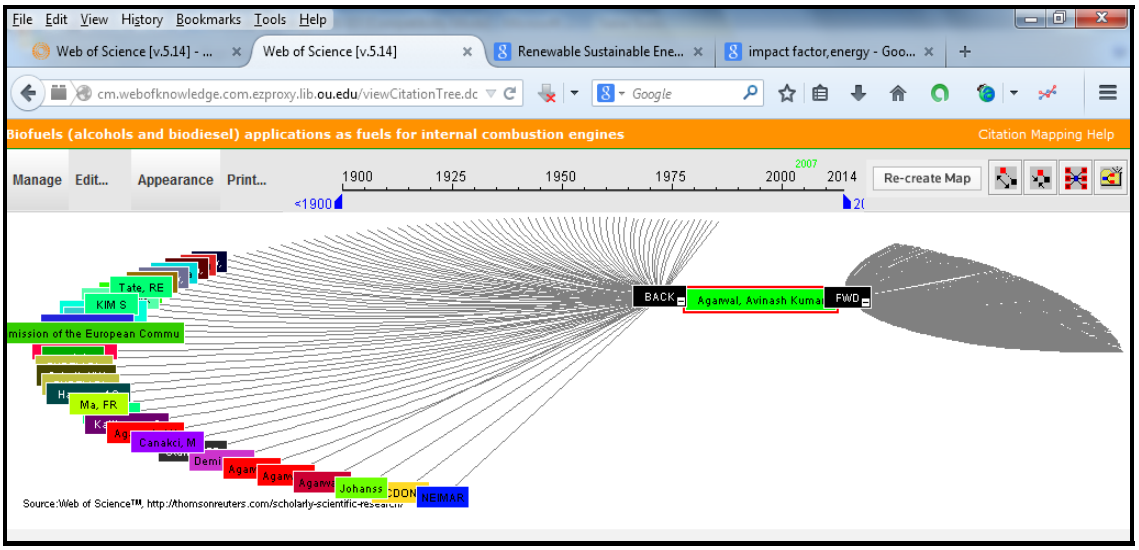
S. No	Name of the Journal	Records	Percent of 652	Impact Factor
1	Renewable Sustainable Energy Reviews	122	18.712	5.510
2	Renewable Energy	44	6.748	3.842
3	Energy Policy	32	4.908	3.402
4	International Journal of Hydrogen Energy	27	4.141	4.086
5	Biomass Bioenergy	21	3.221	3.411
6	Energy	19	2.914	4.465
7	Current Science	16	2.454	0.833
8	Journal of Renewable and Sustainable Energy	13	1.994	1.49
9	Energy for Sustainable Development	13	1.994	2.360
10	Bio-resource Technology	11	1.687	5.600

It is found from analysis that the Indian literature output on renewable energy has been proliferated in to 203 journals. Among them top 10 journals alone could contribute 57.74 percent of literature output (138 publications). The top 3 positions in terms of the number of publications for the journal "Indian Journal of Paediatrics (6.7%), Indian Journal of Social Work (5.02%) and the "International journal of educational development (3.34%).

Table IX: Highly cited papers on Renewable Energy

S.No	Author	Title	Journal	Vol. Iss.Pgs.Year	Times Cited
1	Agarwal, Avinash Kumar	Biofuels (alcohols and biodiesel) applications as fuels for internal combustion engines	Progress In Energy And Combustion Science	Vol: 33 Iss: 3 Pages: 233-271 JUN 2007	619
2	Pohekar, SD; Ramachandran, M	Application of multi-criteria decision making to sustainable energy planning - A review	Renewable & Sustainable Energy Reviews	Vol: 8 Iss:4 Pages: 365-381 AUG 2004	253
3	Ramadhas, AS; Jayaraj, S; Muraleedharan, C	Use of vegetable oils as IC engine fuels - A review	Renewable Energy	Vol: 29 Iss: 5 Pages: 727-742 APR 2004	225
4	Kotay, Shireen Meher; Das, Debabrata	Biohydrogen as a renewable energy resource - Prospects and potentials	International Journal of Hydrogen Energy	Vol: 33 Iss: 1 Pages: 258-263 JAN 2008	199
5	Goyal, H. B.; Seal, Diptendu; Saxena, R. C.	Bio-fuels from thermochemical conversion of renewable resources: A review	Renewable & Sustainable Energy Reviews	Vol: 12 Iss: 2 Pages: 504-517 FEB 2008	182

The above table shows that highly cited papers on renewable energy during the study period. The paper "Biofuels applications a s fuels for internal combustion engines by Agarwal and Avinash Kumar in the journal 'Progress in Energy and Combustion Science, 2007' cited 619 times and got first positioned, which is followed by "Application of multi-criteria decision making to sustainable energy planning - A review" by Pohekar, SD and Ramachandran, M in the journal 'Renewable & Sustainable Energy Reviews' cited 253 times got second position and the paper "Use of vegetable oils as IC engine fuels - A review" by Ramadhas, AS in the journal of 'Renewable Energy, 2004' cited 225times got third position respectively.



Citation map of Agarwal, and Avinash Kumar. Biofuels (alcohols and biodiesel) applications as fuels for internal combustion engines (Times cited- 619)

CONCLUSION

The results based on this analysis the following results were summarized. The research productivity of renewable energy reveals that a regular growth during the study period 2001-2013. The mean relative growth rate is 0.31 and the doubling time is 0.45 years. Top ten authors literature output is16.26 percent and their maximum h-index is 8.Indian Institute of Technology, Delhi have contribute 17.79 percent of records and the major funding agency of Council of Scientific and Industrial Research, CSIR have 3.22 percent of research output on renewable energy. The journal Bio-resource Technology has got high impact factor (5.600) with 11 records. India's contribution on renewable energy output during the study period is 652 only. This number is very low Compare than the other Nations. Sponsoring agencies and Organisations in India to encourage the researchers in the field of renewable energy and bring into being more literature output.

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