



Mapping and Scientometric Measures on Research Publications of Energy Storage and Conversion

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Abstract

The present work investigated mapping and scientometric techniques adopt on the publications towards analysis the research trend in energy storage and conversion. The research was conducted based on Web of Science data for the 1993–2021 periods. The study found out that India's research effort in the energy storage and conversion field was significantly less than world production for all years in the study period from 1993 to 2021. Although the research performance of the contribution of scientists rose to peak levels with over a thousand publications between 2014 and 2021, were the highest-rated collaborative authors with 10 (45.45%) of the publications of the Alagappa University. The main types of sources were published as articles with 23,394 (88.7%) publications. Research articles engaged the first position, Wang Y tops the list with 322 (1.22%) publications, followed by Zhang Y, Wang J, Li Y, Liu J, Zhang L, Liu Y, and Wang L had the 2nd to 8th position for them, of which more than 200 publications testify. It was found that the largest number of published papers in chemistry was 4,444 with 12,103 (45.89%) of the publications, Chinese Peoples were with 12,145 (46.05%) devoted about half of the research publications shared in energy storage and conversion applications.

Keywords Energy · Conversion · Mapping · Scientometrics · Activity index · Network visualization

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1 Introduction

Energy can be defined as the ability to do work. Mainly, the work output depends on the work input [1, 2]. The energy is the most basic infrastructure input for economic growth and development of a country [3–5]. The amount of energy required to run a particular electrical utility can be calculated. The energy is required to meet energy demand in different sectors like domestic, transportation, agricultural and industry [6, 7]. Because of the climate change we need renewable energy to do something about this climate change issues, and we know very clearly about the energy crisis and then people thought about some kind of alternative solution [8–12]. The people were really forced to think about new development and generation of energy from alternative resources [13, 14]. Accordingly, this all together crisis actually forced researchers to think about some kind of alternative solutions and of course we need energy security and sustainability [4, 15]. We have many like solar, wind, geothermal, hydro, bio and tidal energy [16–23]. The use of hydrogen as energy storage is attractive in which excess electrical energy is captured by a photovoltaic module

that is moved to electrolyser to produce stored hydrogen by splitting water, hence, hydrogen gas stored is temporarily fed to a fuel cell bottlenecks [24–27]. Duan and Guan [28] they examined the potential motivation for the convergence of knowledge and found law of the convergence of knowledge, using example of solar energy. The authors set up keyword co-occurrence networks from solar energy literature in 2008–2017 [29–31]. Van Leeuwen and Tijssen [32] discussed combining bibliometric indicators for publication performance. Sanz-Casado et al. [33] analyzed that there will not materialize a greater cooperation of the EU envisaged in wind energy. Zhang et al. [34], Saravanan and Chinnasamy [35], Senthil Kumar and Chinnasamy [36] Radhakrishnan and Chinnasamy [37] Saravanan and Chinnasamy [38] have analyzed connections between scientific work and references. Borri et al. [39] have studied the liquid air energy storage (LAES). Chinnasamy [40] discussed apex graded organizations. Wali [41] examined the bibliometric examination. Barbosa et al. [42] elaborate the 9 years number of publications about EVs.

2 Materials and Methods

The publication trend analyses the research documents based on being recovered from WoS in energy storage and conversion field. The research was measured according to WoS data for 1993–2021. The considerable effort was taken to obtain the data from the database from WoS. The research data comprised in publications number and citations were published and obtained from WoS database for the period of 1993–2021. The study has been discussed, analysis for activity index of world and Indian output, ranked with ten categories, annual world production publications, ranking of sources wise publications, authors, institutions, researchers, counties, journal ranking, contribution to Indian research and it citations, collaboration of research.

Further, the study made analysed ranking of author from Alagappa University. In addition, the study focused on the research measure for the quantitative analysis of the data entity in energy storage and conversion. The study portrays network visualization of the VOS-Viewer for authors, institutions, research areas and countries where research contributions are in energy storage and conversion.

3 Results and Discussion

The publications trend for Indian energy storage and conversion scientists published 918 articles i.e. about 3.53% of world output during 2017–2021, it can be noticed that the

world out of the research as witnesses 64.5% of the publications during 2017–2021. The results are given in Table 1. India's attempt in energy storage and conversion was lower remarkably for all the years in the study period from 1993 to 2021 than the world's output. Even though, the research performance of the scientist's contribution went to peak level more than thousand publications from 2014 to 2021, whereas India's output went to hundred for above specified period of study.

The highest score of AI in the years 1993, 1997 and 2000, were found to be more than 300, on contrarily, the lowest AI were 15 in the years 1996, 1998 and 2001. The publications trend of the world output was increased trend from 2002 to 2006, suddenly the growth of publications found to

Table 1 Activity index of the World and Indian output of energy storage and conversion

Year	World output	Indian output	Activity index ^a
1993	73	10	380
1994	0	9	250
1995	82	0	70
1996	0	5	15
1997	98	13	370
1998	0	5	15
1999	0	3	80
2000	78	9	320
2001	0	5	15
2002	92	7	200
2003	79	6	200
2004	136	12	250
2005	141	8	160
2006	234	9	100
2007	180	15	230
2008	251	13	150
2009	326	18	150
2010	395	28	250
2011	462	35	200
2012	692	28	110
2013	933	41	120
2014	1318	47	100
2015	1641	75	125
2016	1995	86	120
2017	2456	122	140
2018	3126	140	130
2019	3765	195	150
2020	4242	246	160
2021	3147	215	190
	25,942	1405	

^aActivity index has been rounded off to nearest whole number

Table 2 Ranking of the Sources wise distribution of ES&C publications

Rank	Document	Records	%
1	Articles	23,394	88.718
2	Review Articles	2651	10.053
3	Proceedings Papers	1286	4.877
4	Early Access	242	0.918
5	Editorial Materials	169	0.641
6	Meeting Abstracts	112	0.425
7	Book Chapters	29	0.11
8	Letters	18	0.068
9	Corrections	16	0.061
10	Notes	6	0.023
11	Retracted Publications	4	0.015
12	Biographical-Items	1	0.004
13	Book Reviews	1	0.004
14	Data Papers	1	0.004
15	News Items	1	0.004

Table 3 Ranking of authors for the publications in the field of ES and conversion

Rank	Author	Records	%
1	Wang Y	322	1.221
2	Zhang Y	273	1.035
3	Wang J	257	0.975
4	Li Y	229	0.868
5	Liu J	224	0.849
6	Zhang L	222	0.842
7	Liu Y	208	0.789
8	Wang L	202	0.766
9	Wang H	198	0.751
10	Zhang J	188	0.713
11	Li J	187	0.709
12	Zhang H	173	0.656
13	Wang X	170	0.645
14	Zhang X	160	0.607
15	Chen J	156	0.592
16	Yang Y	151	0.573
17	Yang J	150	0.569
18	Chen Y	148	0.561
19	Zhao Y	145	0.55
20	Zhang Q	144	0.546
21	Li L	142	0.539
22	Wang C	136	0.516
23	Wang Q	127	0.482
24	Liu H	125	0.474
25	Li Q	123	0.466

fluctuating trend in the years 2007 and 2021. The study has been witnessed the Indian output and activity index (AI) of the energy storage and conversion literature was uniformly an increasing and a decreasing trend throughout study. On other hand, the Indian output of the publications gradually grown from 2015 to 2021.

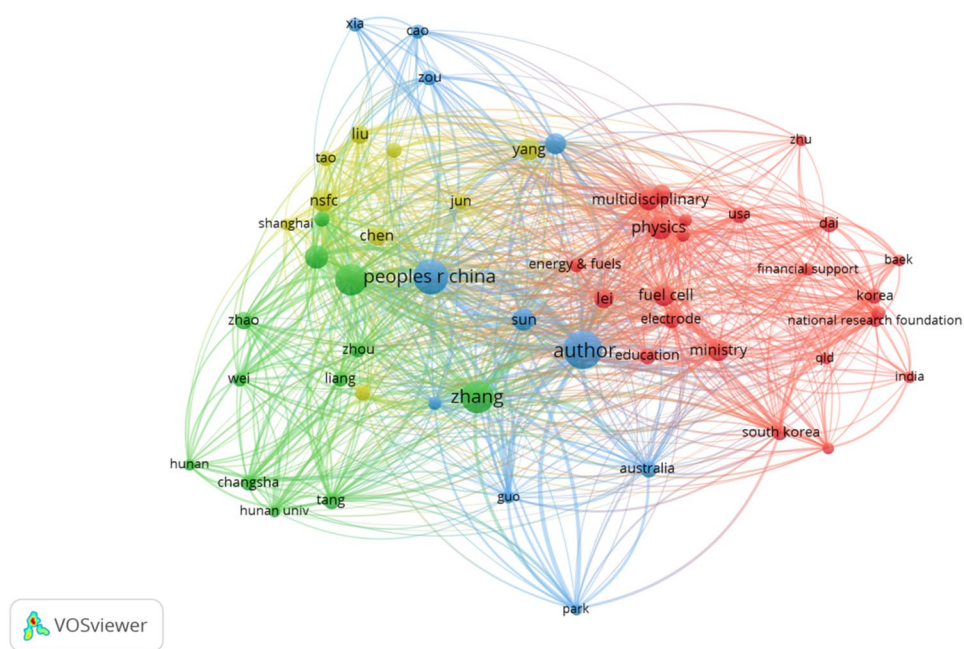
The analysis made under the category of the sources accordingly publications distribution for ranking measure in the field of energy storage and conservation. Table 2 revealed major types of sources as articles 23,394 (88.7%) of the publications. Research articles engage top position, followed by Review Articles 2651 (10%), Proceeding papers 1286 (4.8%), Early Access 242 (0.9%), Editorial materials 169 (0.64%), Meeting Abstracts 112 (0.42%), Book Chapters 29(0.11%), Letters 18 (0.6%), Corrections 16 (0.06%), Notes 6 (0.02%), Retracted Publications 4 (0.05%) of the publications. Furthermore, the study discuss that the rest of the four sources are Bibliographical items, Book Review, Data papers and News items show the publications was one (Table 3).

The authors are prime points to carry out the driving force and each researcher task to produce worthy contribution to research domain and enhancement of research and development of the field study. Table 2 clears the ranking of the authors witness the research contribution accomplished Wang Y with 322 (1.22%) of the publications as top position, followed by Zhang Y, Wang J, Li Y, Liu J, Zhang L, Liu Y and Wang L hold 2nd to 8th position for them witnessing more than 200 publications. The study is discussed that the ranking of authors listed in the series, Wang H, Zhang J, Li J, Zhang H, Wang X, Zhang X, Chen J, Yang Y, Yang J, Chen Y, Yang Y, Yang J, Chen Y, Zhao Y, Zhang Q, Li L, Wang C, Wang Q, Liu H, Li Q were contributed more than hundreds of publications in energy storage and conversion. Figure 1 displays network visualization author for collaboration of research at globally in energy storage and conversion.

The study considers the Ranking of the institutions level. The details are given for the top 50 institutions (Table 4). The Chinese Academy of Sciences is 2072 (7.8%) of publications followed by United States Department of Energy DOE with 936 (3.55%) and University of Chinese Academy of Sciences CAS with 530 (2.0%). As can see, there are twenty-two research institutions and organizations have contributed more than one percentage of the publications. The rest of the twenty-eight research institutions and Universities are holding that less than one percentage of the publications and witnessed each of more than hundred (Table 5).

The research areas selected for this analysis were the 50 subject categories from Web of Science for 1993–2021. Table 6 shows their largest number of documents published

Fig. 1 Mapping of countries and with author collaboration (Network Visualization)



in the field of Chemistry with 12,103 (45.89%) of the publications, it is considering the top research field among 50 subjects were identified for the study followed Material Science (38.19%), Energy Science (33.65%), Science and Technology other topics (20.53%), Physics (19.32%), Engineering (17.55%), Electrochemistry (10.91%), Thermodynamics (10.13%), Mechanics (8.7%), Environmental Science Ecology (2.72%), Metallurgy Metallurgical Engineering (1.83%), Polymer Science (1.20%) and Biotechnology Applied Microbiology (1.01%) of the publications are recorded in the Raked subjects. Further, the ranked subjects categories rest of the 32 research fields are witnessed 2328 (8.82%) of the publication share in the core area of research in energy storage and conversion, as explained in Fig. 2, the network visualization of research areas and counties collaboration in energy storage and conversion research (Fig. 3).

A top 50 countries have contributed to the energy storage and conversion field, as disclose in the Table 6. It is noticed that china peoples commits about nearly half of the publications of the literature to ES&C research with 12,145 (46.05%). This indicates that China People was leading in the ES&C field of research. The USA was the second position which indicates less than 20% of publications witnessing in the field of research. Interestingly, the European countries, Germany (5.54%), England (3.89%), Italy (3.06%), France (2.51%), Spain (2.35%), Denmark (2.10%), Switzerland (1.5%), Sweden (1.41%), Netherlands (1.24%) and Turkey (1.05%) of the publications brought to the research in energy storage and conversion. The research publications

concerned among the ranking of counties, India was fifth 1424 (5.4%) among the ranked countries on the production research documents in the relevant area. It concludes that Indian scientists taken keen interest to concentrate for developing energy sources in terms renewable energy, wind energy, solar energy etc. The production concerning the research with energy resources across the world reveals the steadfast build the infrastructure for strengthening the R&D. Researchers from China People, United States South Korea, Germany, India, Japan Australia and England have been publishing more than thousand research documents in the field and importantly intensified research in field of energy storage and conversion. Furthermore, it is discussed that ranked counties of the research productivity there were 29 counties included developed counties less than one percentage of publications for 3614 (13.70%) of the research documents have been conglomerated in energy storage and conversion.

The study has been analysing research productivity, to analyse the study in research relate to energy storage and conversion. The study could be pointed out those frontiers in research. The metrics and analytics of the prolific journals identified on the based research quantum of the publications across world in the field concerned. Table 7 summarizes top fifty journals. Energy conversion and management was considering the top journal which has published 2145 (8.13%) of the research records, followed by the material component of research publications consecutively, the second, third, fourth and fifth place hold Journal of Materials Chemistry A 920 (3.51%), Materials

Table 4 Ranking of the institutions for the collaboration of research

Rank	Author	Records	%
1	Chinese Academy of Sciences	2072	7.858
2	United States Department of Energy DOE	936	3.55
3	University of Chinese Academy of Sciences CAS	530	2.01
4	Tsinghua University	471	1.786
5	Huazhong University of Science Technology	457	1.733
6	University of Science Technology of China CAS	451	1.71
7	University of California System	421	1.597
8	Nanyang Technological University	413	1.566
9	Nanyang Technological University National Institute of Education Nie Singapore	413	1.566
10	Helmholtz Association	407	1.543
11	Centre National de la Recherche Scientifique CNRS	406	1.54
12	Indian Institute of Technology System IIT System	373	1.415
13	Technical University of Denmark	360	1.365
14	Nankai University	345	1.308
15	South China University of Technology	322	1.221
16	Tianjin University	317	1.202
17	Harbin Institute of Technology	312	1.183
18	Zhejiang University	307	1.164
19	Xi An Jiaotong University	301	1.141
20	Central South University	280	1.062
21	Shanghai Jiao Tong University	268	1.016
22	University System of Georgia	265	1.005
23	Peking University	255	0.967
24	National University of Singapore	248	0.94
25	Georgia Institute of Technology	247	0.937
26	Suzhou University	236	0.895
27	Beijing University of Chemical Technology	233	0.884
28	Dalian University of Technology	230	0.872
29	Fudan University	225	0.853
30	Seoul National University SNU	221	0.838
31	HUNAN UNIVERSITY	203	0.77
32	Shandong University	203	0.77
33	Beijing Institute of Technology	202	0.766
34	Jilin University	201	0.762
35	Zhengzhou University	201	0.762
36	Max Planck Society	199	0.755
37	Beijing Normal University	195	0.74
38	University of Texas System	191	0.724
39	University of Wollongong	189	0.717
40	Council of Scientific Industrial Research CSIR India	181	0.686
41	Wuhan University of Technology	181	0.686
42	Nanjing University	176	0.667
43	Karlsruhe Institute of Technology	175	0.664
44	Lawrence Berkeley National Laboratory	175	0.664
45	University of Chicago	174	0.66
46	Wuhan University	174	0.66
47	Consiglio Nazionale Delle Ricerche CNR	172	0.652
48	Xiamen University	168	0.637
49	Qingdao University Of Science Technology	167	0.633
50	Sun Yat Sen University	165	0.626

Table 5 Ranking of the research areas vs. publications count

RANK	RESEARCH AREA	RECORDS	%
1	Chemistry	12,103	45.899
2	Materials Science	10,071	38.193
3	Energy Fuels	8874	33.653
4	Science Technology Other Topics	5414	20.532
5	Physics	5201	19.724
6	Engineering	4734	17.953
7	Electrochemistry	2879	10.918
8	Thermodynamics	2673	10.137
9	Mechanics	2313	8.772
10	Environmental Sciences Ecology	719	2.727
11	Metallurgy Metallurgical Engineering	485	1.839
12	Polymer Science	318	1.206
13	Biotechnology Applied Microbiology	268	1.016
14	Instruments Instrumentation	239	0.906
15	Agriculture	233	0.884
16	Nuclear Science Technology	212	0.804
17	Computer Science	182	0.69
18	Biochemistry Molecular Biology	147	0.557
19	Optics	137	0.52
20	Automation Control Systems	128	0.485
21	Crystallography	118	0.447
22	Telecommunications	106	0.402
23	Geology	58	0.22
24	Food Science Technology	57	0.216
25	Plant Sciences	57	0.216
26	Biophysics	52	0.197
27	Construction Building Technology	50	0.19
28	Water Resources	47	0.178
29	Business Economics	40	0.152
30	Transportation	31	0.118
31	Spectroscopy	30	0.114
32	Marine Freshwater Biology	29	0.11
33	Meteorology Atmospheric Sciences	29	0.11
34	Microbiology	29	0.11
35	Cell Biology	28	0.106
36	Forestry	26	0.099
37	Dentistry Oral Surgery Medicine	24	0.091
38	Mathematics	22	0.083
39	Mineralogy	22	0.083
40	Fisheries	21	0.08
41	Oceanography	21	0.08
42	pharmacology pharmacy	21	0.08
43	Endocrinology Metabolism	19	0.072
44	Geochemistry Geophysics	19	0.072
45	Mining Mineral Processing	18	0.068
46	Nutrition Dietetics	18	0.068
47	Sport Sciences	18	0.068
48	Life Sciences Biomedicine Other Topics	14	0.053

Table 5 (continued)

RANK	RESEARCH AREA	RECORDS	%
49	Operations Research Management Science	14	0.053
50	Acoustics	12	0.046

letters 895 (3.39%), International Journal of Hydrogen Energy with 677(2.56%) and ACS Applied materials interfaces with 623 (2.36%) publications. The study could be deducted from above the discussion, the thrust area research focuses the Energy substances, the title relevance to the prolific journals include 3384 (12.75%) of the publications in respect of International Journal of Hydrogen energy with 677 (2.56%), Nano Energy 348 (1.32%), IEE Transaction Energy Conversion and storage 261 (0.99%), Energy 247 (0.93%), Energies 236 (0.89%), Energy Environmental Science 212 (0.80%), ACS Applies Energy Materials 181 (0.68%), Solar Energy Materials and Solar cells 169 (0.64%), Energy Fuels 147 (0.55%), Renewable Sustainable Energy Reviews 137 (0.5%), Renewable Energy 134 (0.50) and Energy Technology 115 (0.43%) were hold the places Fourth, Eighth, Thirteenth, Nineteenth, Twentieth, Twenty first, Twenty Third, Twenty fourth, Twenty ninth, Thirty third, Thirty Seventh, Thirty Eighth, Forty third and Forty ninth placed in the ranked series.

The study explores collaboration of the research trend of the publications among the Indian researchers in energy storage and conversion. Table 8 employs relative citation impact indicators (RCI) which calculates citations impact for publications in the respective years. The publication trend between 73 and 4242 in the years 1993 and 2020 respectively, whereas, the Citations calculate from 7 it went up 6784 in the years 1995 and 2020 respectively. On the other hand, the study has been witnessed the activity index of the Publications and Citations for impact of the publications range between 05 and 230 in the year 1993 and 2021 respectively. Obviously, it can see that when publications grow the citations will be increased; there is no proportion count between publications and Citations. The activity index count was increased year by year exclude during 2002, 2004, 2006, 2008, 2012 and 2014.

Table 8 explored collaboration among 25 research institutes research mutual with Alagappa University in Energy Storage and Conversion. It consists of twenty-two publications witnesses on the research contribution of Alagappa University in research. The study found that western Norway University of Applied Sciences was highest collaboration

Table 6 Ranking of the countries on the publications in the field of ES&C

Rank	Country	Records	%
1	Peoples R China	12,145	46.058
2	USA	4601	17.449
3	South Korea	1691	6.413
4	Germany	1463	5.548
5	India	1424	5.4
6	Japan	1191	4.517
7	Australia	1063	4.031
8	England	1028	3.899
9	Italy	809	3.068
10	Canada	758	2.875
11	Singapore	683	2.59
12	France	663	2.514
13	Spain	621	2.355
14	Denmark	554	2.101
15	Iran	411	1.559
16	Switzerland	403	1.528
17	Taiwan	378	1.434
18	Sweden	373	1.415
19	Saudi Arabia	364	1.38
20	Netherlands	327	1.24
21	Turkey	277	1.05
22	Poland	242	0.918
23	Malaysia	230	0.872
24	Russia	213	0.808
25	Brazil	189	0.717
26	Egypt	187	0.709
27	Pakistan	182	0.69
28	Belgium	181	0.686
29	Portugal	171	0.648
30	Norway	158	0.599
31	Scotland	140	0.531
32	Greece	137	0.52
33	Finland	128	0.485
34	Israel	122	0.463
35	Austria	121	0.459
36	Czech Republic	120	0.455
37	South Africa	117	0.444
38	Thailand	111	0.421
39	Romania	109	0.413
40	Ireland	99	0.375
41	Mexico	93	0.353
42	Algeria	82	0.311
43	Vietnam	80	0.303
44	U Arab Emirates	78	0.296
45	Qatar	63	0.239
46	New Zealand	60	0.228
47	Argentina	57	0.216
48	Croatia	50	0.19
49	Iraq	47	0.178
50	Serbia	47	0.178

with Alagappa University, it was published 5 (22.72%) of the publications, followed Chungnam National University, King Saud University and SRM Institute of Science Technology Chennai have secured third position among the collaboration research with Alagappa University. The study explores more than 90% either domestically or internationally by the Universities with Alagappa University. It is observing patterns in various sectors determined that research collaboration ensue between Research Institutes and Universities in the field of Energy Storage and Conversion. Further, it calculates eight Universities and Research institutes was collaboration of research by two of each for 72.72% of the publications, there were 12 Universities and Research institutes with 54.54% of the publication contributed each of one (Table 10).

The Ranking of authors demonstrate research evidence in Energy Storage and Conversion in Alagappa University. The Alagappa University researchers were taken up different projects funded by Government of India for the Dept. of Science and Technology, Renewable energy, RUSA 2.0 and so on. There are committed and devoting for fruitful research successfully completing in the Energy Domain. Table 9 depicts the ranking of the authors from Alagappa University is witnessed top collaborative researchers of the publications to their credit for secured different places of the collaborative publications in the field of ES and Conversion.

4 Discussions

The research literature of Energy Storage and Conversion was extracted from Web of Science. The study has been undertaken with applied Scientometrics and Mapping techniques adopt for analysing the data for period of 1993–2021. The study has been analysed and results of research is summarized here, The Indian research publications in the field of Energy Storage and Conversion Scientists published 918 articles i.e. about 3.53% of world output during 2017–2021 the world out of the research as witnesses 64.5% of the publications during 2017–2021. The highest score of AI in the years 1993, 1997 and 2000, found to be AI were more than 300, on contrarily, the lowest AI were 15 in the years 1996, 1998 and 2001. The major type of source in account of Journal articles share with 23,394 (88.7%) of total publications in the field of energy storage and conversion. It witnesses the Journal articles engage top position, followed by Review Articles 2651 (10%). The prolific author category was found Wang Y with 322 (1.22%) of the publications as top position, followed by Zhang Y and Wang J in the series of first, Second and Third position. The Chinese Academy of Sciences is 2072 (7.8%) of publications was top position among

Fig. 2 Network visualization of research areas and counties collaboration

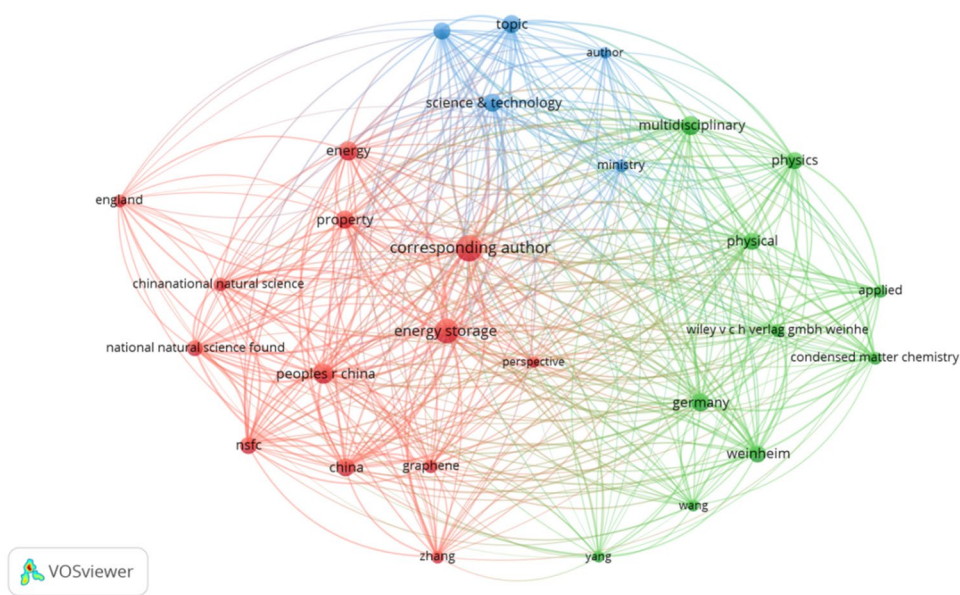
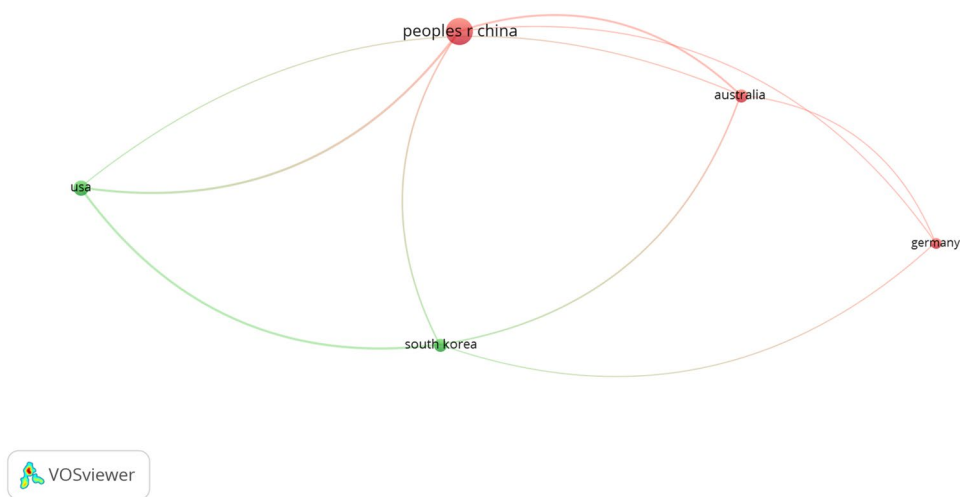


Fig. 3 Network visualization of research collaboration among countries



the fifty institutions. The leading country wise publications china peoples commits about nearly half of the publications of the literature to ES&C research with 12,145 (46.05%). This indicates that China People was leading in the ES&C field of research. The top fifty journals, Energy conversion and Management was considering the top journal which has published 2145 (8.13%) of publications in the field of relevant study. The Indian activity index count was increases year by year exclude during 2002, 2004, 2006, 2008, 2012

and 2014. The result of study is discussed that western Norway University of Applied Sciences was highest collaboration with Alagappa University. Alagappa University is witnessed top collaborative researchers with 10 (45.45%) of the publications in the core filed of energy storage and conversion.

Table 7 Prolific ranked journals in energy storage and conversion

Rank	Journal	Records	%
1	Energy Conversion and Management	2145	8.135
2	Journal of Materials Chemistry A	926	3.512
3	Materials Letters	895	3.394
4	International Journal of Hydrogen Energy	677	2.567
5	ACS Applied Materials Interfaces	623	2.363
6	Electrochimica Acta	537	2.036
7	Journal of Power Sources	512	1.942
8	Nano Energy	348	1.32
9	Applied Energy	335	1.27
10	RSC Advances	330	1.251
11	Nanoscale	329	1.248
12	Advanced Energy Materials	319	1.21
13	IEEE Transactions on Energy Conversion	307	1.164
14	Chemical Engineering Journal	297	1.126
15	Journal of Alloys and Compounds	292	1.107
16	Advanced Functional Materials	272	1.032
17	Advanced Materials	265	1.005
18	Journal of Physical Chemistry C	265	1.005
19	Journal of Electrochemical Energy Conversion and Storage	261	0.99
20	Energy	247	0.937
21	Energies	236	0.895
22	Small	219	0.831
23	Energy Storage Materials	213	0.808
24	Energy Environmental Science	212	0.804
25	ACS Sustainable Chemistry Engineering	211	0.8
26	ACS Nano	201	0.762
27	Angewandte Chemie International Edition	193	0.732
28	Journal of the Electrochemical Society	189	0.717
29	ACS Applied Energy Materials	181	0.686
30	Applied Surface Science	181	0.686
31	Chemsuschem	175	0.664
32	IEEE Transactions on Power Electronics	175	0.664
33	Solar Energy Materials and Solar Cells	169	0.641
34	Journal of Energy Chemistry	153	0.58
35	Physical Chemistry Chemical Physics	153	0.58
36	Chemistry A European Journal	150	0.569
37	Energy Fuels	147	0.557
38	Chemelectrochem	146	0.554
39	Solar Energy	144	0.546
40	Carbon	141	0.535
41	IEEE Transactions on Industry Applications	137	0.52
42	Renewable Sustainable Energy Reviews	137	0.52
43	Renewable Energy	134	0.508
44	Applied Catalysis B Environmental	131	0.497
45	Chemistry of Materials	131	0.497
46	Scientific Reports	131	0.497
47	Journal Of The American Chemical Society	128	0.485
48	Nature Communications	125	0.474
49	Energy Technology	115	0.436
50	Journal Of Colloid And Interface Science	114	0.432

Table 8 Indian's contribution and their citations with activity index

Year	Indian output	Citations	Activity index
1993	73	1	05
1994	0	0	0
1995	82	7	05
1996	0	0	0
1997	98	14	20
1998	0	0	0
1999	91	27	35
2000	78	36	60
2001	0	0	0
2002	92	38	50
2003	79	61	90
2004	136	91	80
2005	141	102	85
2006	234	102	50
2007	180	151	100
2008	251	163	80
2009	326	269	100
2010	395	385	120
2011	462	526	135
2012	692	594	100
2013	933	811	105
2014	1318	1085	100
2015	1640	1458	105
2016	1995	2128	130
2017	2455	2845	140
2018	3125	3692	140
2019	3765	5057	160
2020	4242	6784	190
2021	3133	6065	230
	26,016	32,554	

5 Conclusions

The study has shown that the trend in research is booming and that funding and infrastructure are essential for good research. Research is constant scientific and researchers focus on the novel field of energy storage and conversion. Indian scientists are more passionate about launching projects from various funding organizations, and the Indian government is also giving more priority to natural power generation. Since the products of scientific research are an important part of society, researchers have always attracted their share of research ideas for new innovations and research collaboration that attract more attention from lay people and fellow scientists. Research products are most important communication channels to measure the influence of scientific knowledge on scientific knowledge. Publications are considered an indicator of the scientific contribution of the scientist in a domain. Scientific

Table 9 Research collaboration of Alagappa University

Rank	Institution	Records	%
1	Alagappa University	22	100
2	Western Norway University of Applied Sciences	5	22.727
3	Chungnam National University	3	13.636
4	King Saud University	3	13.636
5	SRM Institute of Science Technology Chennai	3	13.636
6	Chang Gung University	2	9.091
7	Council of Scientific Industrial Research CSIR India	2	9.091
8	CSIR Central Electrochemical Research Institute CECRI	2	9.091
9	Lamar University	2	9.091
10	Ming Chi University of Technology	2	9.091
11	Nanyang Technological University	2	9.091
12	Nanyang Technological University National Institute of Education Singapore	2	9.091
13	Texas State University System	2	9.091
14	Anna University	1	4.545
15	Anna University Chennai	1	4.545
16	Auxilium Coll Autonomous	1	4.545
17	CSIR CECRI	1	4.545
18	Ithemba Labs	1	4.545
19	Kalasalingam Academy of Research Education	1	4.545
20	King Khalid University	1	4.545
21	Kumoh National University Technology	1	4.545
22	Kyung Hee University	1	4.545
23	National Research Foundation South Africa	1	4.545
24	Presidency Coll Autonomous	1	4.545
25	Sejong University	1	4.545

publications are concrete objects, the creation of which essentially uses similar processes and criteria across entire scientific spectrum. Highly cited literatures are considered for analysing battery energy storage systems. The study has been identified and analysed the highly cited articles to guide future LIB research, factors, issues and challenges

of the research publications trend was discussed in energy storage and conversion is highlighted. The study is elaborated the Scientometric analysis and mapping techniques.

Table 10 Ranking of the authors in Alagappa University

Rank	Author	Records	%
1	Ravi G	10	45.455
2	Yuvakkumar R	10	45.455
3	Velauthapillai D	5	22.727
4	Rani BJ	4	18.182
5	Sivakumar M	4	18.182
6	Subadevi R	4	18.182
7	Babu ES	3	13.636
8	Ameen F	2	9.091
9	Arjunan P	2	9.091
10	Dang C	2	9.091
11	Ganesh V	2	9.091
12	Gnanamuthu RM	2	9.091
13	Guduru RK	2	9.091
14	Hong SI	2	9.091
15	Kannan K	2	9.091
16	Karuppiah C	2	9.091
17	Kouthaman M	2	9.091
18	Kumar P	2	9.091
19	Kumaraguru S	2	9.091
20	Kumaran V	2	9.091
21	Piraman S	2	9.091
22	Saravanakumar B	2	9.091
23	Swathi S	2	9.091
24	Thambidurai M	2	9.091
25	Vidhya MS	2	9.091
26	Yang CC	2	9.091
27	Al-Sehemi AG	1	4.545
28	Alagar S	1	4.545
29	Alfarraj S	1	4.545
30	Alharbi SA	1	4.545
31	Alnadhari S	1	4.545
32	Arularasu MV	1	4.545
33	Dharmalingam P	1	4.545
34	Foo S	1	4.545
35	Ganesan V	1	4.545
36	Guruviah PK	1	4.545
37	Harikesh PC	1	4.545
38	Ilangovan R	1	4.545
39	Jeon HW	1	4.545
40	Kaliammal R	1	4.545
41	Kanimozhi K	1	4.545
42	Karthikeyan C	1	4.545
43	Karthikeyan GG	1	4.545
44	Karuppuchamy S	1	4.545
45	Kaviyarasu K	1	4.545
46	Keerthana S	1	4.545
47	Kesavan T	1	4.545
48	Kim S	1	4.545
49	Kumar GG	1	4.545
50	Kumar MK	1	4.545

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