Wind Energy Research Publications in India from Scopus Database During 2016 to 2025: A Scientometric Analysis

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Abstract: ***This study examines wind energy research publications produced by Indian researchers during 2016-2025 using data retrieved from the Scopus database. A scientometric approach was employed to analyse publication growth, document types, authorship patterns, collaboration trends, leading authors, institutions, keywords, citations, and highly cited papers. A total of 6,317 publications were identified, representing 16.05% of global wind energy research output during the study period. The highest publication output was recorded in 2024 with 942 publications. Conference papers constituted the largest document type (46.73%). Singh, B. emerged as the most productive author, while the Indian Institute of Technology, New Delhi, was the leading institution. The average degree of collaboration was 0.97, indicating strong collaborative research activity. Saudi Arabia was the leading international research partner. Citation analysis showed that 21.78% of publications received more than ten citations, whereas 25.53% remained uncited. The findings highlight the growth, collaboration patterns, and research impact of Indian wind energy research and provide useful insights for researchers and policymakers.***

Keyword: Wind Energy, Scientometric Analysis, Bibliometrics, Research Productivity, Collaboration Pattern, Citation Analysis, India, Scopus Database

1. Introduction

Wind energy is one of the most radical forces that are transforming the world's electricity scenario in the twenty-first century. Based on an ancient tradition, the harnessing of wind, which once was a small-scale, rudimentary industrial activity, has over the centuries evolved into a large-scale, highly industrialized industry. In the various continents now, the towering turbines quietly rotate above the hillsides, plains, and open seas silently, feeding clean electricity into the grids that run various hospitals, factories, and households as well [1]. Wind energy, which harnesses the kinetic energy of moving air to generate electricity, has emerged as one of the fastest-growing sources of clean power worldwide, driven by the need to reduce dependence on fossil fuels and lower greenhouse gas emissions [1, 2].

One of the principles that a wind turbine works on is a beautiful mechanical simplicity. The wind provides a force to aerodynamically designed blades, which cause a rotation around a central hub. This rotation causes the shaft to rotate, and the mechanical energy is converted into electrical energy and passed to the grid. Blade pitch control systems are a continuous adjustment of the pitch of the blades based on changing wind conditions to optimize energy collection and to protect the machinery during extreme gusts [4].

The economic argument in favour of wind energy has changed radically during the past ten years. The cost of electricity generation through wind has reduced by estimated seven-percentage points since 2010, making it one of the lowest sources of electricity generation in the world [2]. On an annual basis, Denmark produces over 50 percent of national electricity using wind. The offshore wind industry of the United Kingdom has grown to an extent that individual installations are providing power to more than one million households [1,4].

Intermittency is the most widely mentioned drawback of wind power. The amount of electricity generated varies with the speed of the wind, and this presents a challenge to the grid operators who have to maintain a continuous balance between supply and demand. Integration of large-scale battery storage, interconnected grid infrastructure, and smart demand management systems are progressively serving this constraint along with developments in weather forecasting, which have enhanced predictability of wind output [3, 5].

1.1 Scientometrics

Scientometrics is a branch of the broader field of Information Science that focuses on the quantitative analyse of science, technology, and innovation. It involves measuring and evaluating scientific literature, research productivity, and the impact of scholarly work using statistical and mathematical methods. The term was popularized by Vasily Nalimov [6] in the 1960s, who defined scientometrics as the study of the development of science as an informational process. Over time, it has become an essential tool for researchers, institutions, and policymakers to assess research performance and guide decision-making.

Scientometric studies typically rely on bibliometric data such as publications, citations, authorship patterns, and collaboration networks. [7] Tools like citation analyse, impact factor measurement, and h-index evaluation help determine the influence and quality of research outputs. Databases such as Web of Science, Scopus, and Google Scholar provide the necessary data for such analyses. Scientometrics is widely applied in research evaluation, science policy, academic rankings, and the study of emerging research trends, making it a vital component in understanding the dynamics of scientific progress.

2. Review of Literature

Raju Vaishya et al., [8] (2025) analyse the highly cited papers in spine research from India between 1995–2024 with 105 publications. Trends in publications, document types, affiliations, collaborative networks, and citation patterns were the main topics of this study. 73.33% of publications were original research articles, with an average of 102.37 citations per document. The United States was the main partner in the 31 countries that collaborated. Among the leading contributors were Indian organizations like the All India Institute of Medical Science in New Delhi and Ganga Hospital in Coimbatore. Indian authors, most notably S. Rajasekaran and AK Jain. Vivekanandhan S et al., [9] (2016) examines the pollution control research contribution in India from Scopus database from 2003 to 2014 with 28445 research publications in global and 1551publications in India. 60 research institutions of India were responsible for placing India in the 3rd place for publishing 1551. Further, the analyse revealed that, year wise country publications with ranking and the share of India. The study identified the international collaborative paper and publication efficiency index. Reetu Verma et al., [10] (2025) analysed the IOT research publications between 2015–2024 from Scopus database and the study observed maximum of 1852 publications in the year, Kumar N was the highly impactful author with an h-index of 48, g-index of 86, and with 148 publications. IEEE Internet of Things Journal was 284 Publications with 11497 citations were the most influential journal.

3. Objectives of the study

- To identify the year wise growth of publications
- To determine the types of documents
- To analyse the top 10 authors' contributions
- To study the degree of collaboration and authorship pattern
- To analyse the collaborated countries
- To identify keyword trends and top 10 institutions' contributions
- To study the citation range and highly cited publications.

4. Methodology & Limitation

This study attempts to analyze the growth of wind energy research publications in India from the Scopus database during the period of 2016 – 2025. The search keyword is Your query: (TITLE-ABS-KEY ("Wind Energy") AND PUBYEAR > 2015 AND PUBYEAR < 2026 AND (LIMIT-TO (AFFILCOUNTRY,"India"))). The data for this study were collected on 10.04.2026

The collected dataset was subsequently analysed using advanced, open-source bibliometric tools, Vosviewer, Biblioshiny-R and MS Excel. The study identified quantitative data on the literature growth, document type, top authors and Institution, h-index, degree of collaboration, authorship pattern, collaborating countries, keyword analyse, citation range and highly cited publications.

5. Framework of the Research

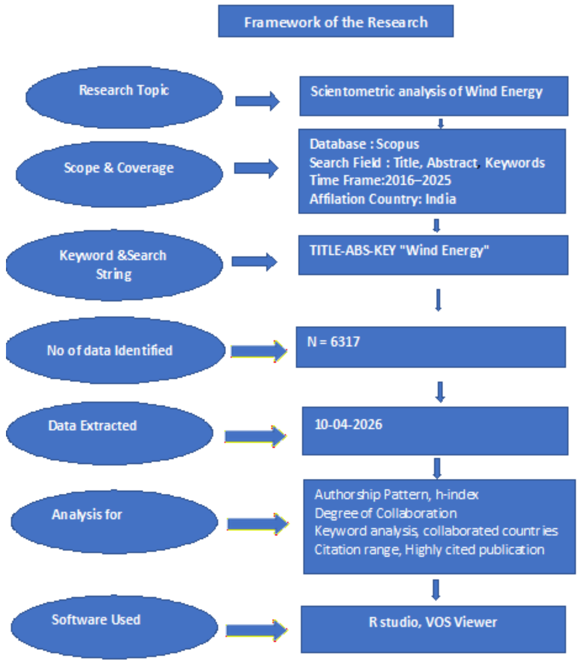

Figure 1: Framework of the research

6. Analysis and Interpretation

Table 1 shows the overall research output in wind energy research publications in India during the study period of 2016-2025 from the Scopus database, with a total of 6317 publications and 64257 citations, and the publications are published in 1923 different types of sources. This study confirmed that 6317 publications are used for 292079 references, and the average reference per publication is 46.24 references. This study identified a total of 11,974 authors involved in wind energy research in India; out of those, 162 publications are single-author, and the remaining 6,155 publications are multi-author documents. The overall study identified that 144 authors are involved in the research contribution in one document.

Table 1: Main Information about the study

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2016:2025
Name of the Keyword for this study	Wind Energy
Affiliation Country	India
Sources (Journals, Books, etc)	1923
Documents	6317
Total No of Citations	64257
Average citations per doc	10.16
References	292079
Average reference per paper	46.24
Author's Keywords	12732

AUTHORS	
Authors	11974
Authors of single-authored docs (Authors in only one paper)	144
AUTHORS COLLABORATION	
Single-authored docs	162
Multiple authors documents	6155

6.1 Year Wise Growth

This study aims to analyze the growth of wind energy research publications in India during 2016 to 2025 from table 2 and figure 2. During the study period, a total of 39357 wind energy research publications were published globally. Out of those, 6317(16.05%) research publications are published in India with 64257 citations and CPP is 10.17. From the study of India, a maximum of 942 (14.91%) publications, 4572 citations and 4.85 CPP in the year 2024.

6.2 Document Type

Table 3: Document types

S. No	Document Type	No of Papers	%
1	Conference Paper	2952	46.73
2	Article	2663	42.16
3	Book Chapter	449	7.11
4	Review	203	3.21
5	Book	25	0.40
6	Retracted	12	0.19
7	Erratum	5	0.08
8	Editorial	4	0.06
9	Letter	2	0.03
10	Data Paper	1	0.02
11	Note	1	0.02
Total		6317	100.00

Table – 3 Identified the types of documents published during the study period in wind energy research publications in India for the selected 10 year study period. This study identified that a maximum of 2952 (46.73%) wind energy research publications are published by India as conference papers, followed by articles with 2663 (42.16%) publications. The book chapter with 449 (7.11%) was placed in third. This study confirmed that out of 6317 wind energy research publications in India, 12 (0.19%) publications are retracted.

6.3 Top 10 Authors Contribution

As table - 4 and figure -3 shows, Singh, B. (IIT New Delhi) was the most productive author, with 98 publications (1.55%), 1,579 citations, CPP of 16.11, and h-index of 23 in the field of wind energy research, followed by Chatterjee, K. 38(0.6%) publications with 1073 citations, CPP is 28.24 and h-index is 13.

Table 2: Year wise growth

	Global			India				
S. No	Year	No of Paper	%	Year	No of Paper	%	Citations	CPP
1	2016	2670	6.78	2016	349	5.52	7565	21.68
2	2017	2884	7.33	2017	412	6.52	5778	14.02
3	2018	3239	8.23	2018	568	8.99	5769	10.16
4	2019	3479	8.84	2019	504	7.98	7544	14.97
5	2020	3562	9.05	2020	531	8.41	8989	16.93
6	2021	3868	9.83	2021	581	9.20	7441	12.81
7	2022	4471	11.36	2022	814	12.89	9082	11.16
8	2023	4439	11.28	2023	753	11.92	5828	7.74
9	2024	5291	13.44	2024	942	14.91	4572	4.85
10	2025	5454	13.86	2025	863	13.66	1689	1.96
Total		39357	100.00		6317	16.05	64257	10.17

(CPP-Citation per paper)

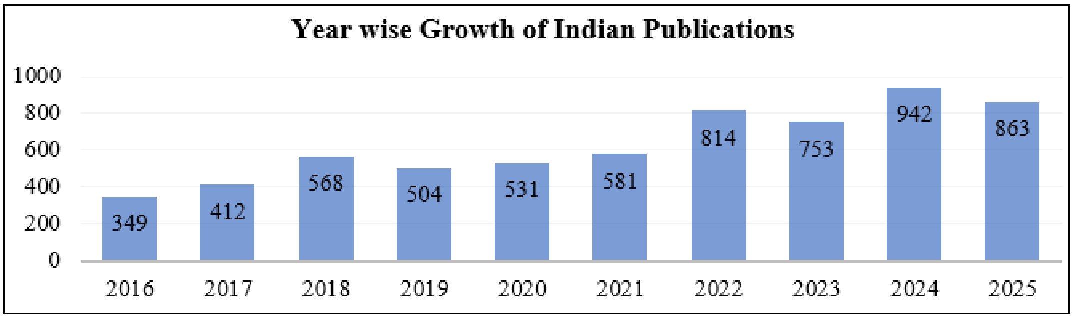

Figure 2: Year wise growth of publications

Table 4: Top 10 authors Publications

S. No	Authors	Institution	Paper	%	Cit.	CPP	h-index
1	Singh, B.	Indian Institute of Technology, New Delhi	98	1.55	1579	16.11	23
2	Chatterjee, K.	Indian Institute of Technology, Dhanbad	38	0.6	1073	28.24	13
3	Roy, P.K.	Kalyani Government Engineering College, The institution will open in a new tab, Nadia	37	0.59	432	11.68	12
4	Nagababu, G.	Pandit Deendayal Energy University The institution will open in a new tab, Gandhinagar.	36	0.57	598	16.61	13
5	Panigrahi, B.K.	Indian Institute of Technology, New Delhi	34	0.54	539	15.85	10
6	Mahela, O.P	Power System Planning Division Rvpn, Jaipur.	31	0.49	1154	37.23	10
7	Bajaj, M.	Graphic Era (Deemed to be University) The institution will open in a new tab, Dehradun	26	0.41	565	21.73	13
8	Sandhu, K.S.	Kurukshetra University, The Institution will open in a new tab, Kurukshetra	23	0.36	242	10.52	9
9	Das, S.	Indian Institute of Technology, New Delhi	22	0.35	186	8.45	7
10	Saket, R.K.	Indian Institute of Technology (BHU) Varanasi the institution will open in a new tab, Varanasi	22	0.35	476	21.64	10
Total			367	5.81	6844	18.65	

Table 5: Degree of Collaboration

S. No	Year	(N_s)	% of 6317	(N_m)	% of 6317	DC=(N_m/(N_s+N_m))
1	2016	6	0.09	343	5.43	0.98
2	2017	11	0.17	401	6.35	0.97
3	2018	21	0.33	547	8.66	0.96
4	2019	27	0.43	477	7.55	0.95
5	2020	13	0.21	518	8.2	0.98
6	2021	19	0.3	562	8.9	0.97
7	2022	13	0.21	801	12.68	0.98
8	2023	14	0.22	739	11.7	0.98
9	2024	22	0.35	920	14.56	0.98
10	2025	16	0.25	847	13.41	0.98
Total		162	2.56	6155	97.44	0.97

Table 8: Top Ten Institutions

S. No	Name of the Institution	No of Papers	% of 6317	Citations	CPP	h-index
1	Indian Institute of Technology, New Delhi, India	210	3.32	3575	17.02	30
2	Vellore Institute of Technology, Chennai, Tamilnadu	192	3.04	3905	20.34	32
3	National Institute of Technology, Kurukshetra, Harayana	125	1.98	1522	12.18	19
4	Indian Institute of Technology Indian School of Mines, Dhanbad, India	109	1.73	2255	20.69	23
5	Anna University, Chennai, Tamilnadu	96	1.52	1386	14.44	20
6	Indian Institute of Technology, Roorkee, Uttarakhand	95	1.50	1153	12.14	17
7	SRM Institute of Science and Technology, Chennai, Tamilnadu	89	1.41	1084	12.18	17
8	Siksha O Anusandhan Deemed to be University, Bhubaneswar, Odisha	88	1.39	831	9.44	16
9	National Institute of Technology, Silchar, Assam	84	1.33	850	10.12	15
10	Pandit Deendayal Energy University, Gandhinagar, Gujarath	82	1.30	976	11.90	17
Total		1170	18.52	17537	14.99	

Amongst the top collaborative countries, Saudi Arabia, Malaysia, the USA, and the United Kingdom are the most collaborated-on countries in the field of study. The majority of authors in Indian Institute of Technology are involved in wind energy research.

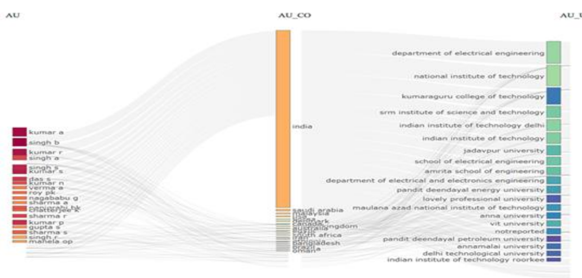

Figure 3: Triple axis map of top authors, countries and institutions

6.4 Degree of Collaboration

The Degree of Collaboration [DC] is a bibliometric indicator used in bibliometric or scientometric to measure the scope of collaborative research. It was proposed by Subramanyam formula in 1983, [11] and used for sivasamy and vivekanandhan [12,13,14,15]

$DC = N_m/N_m+N_s$ whereas, N_m = Number of multi-authored publications and N_s = Number of single-authored publications.
Here, Degree of collaboration DC = 0, ⟹ No Collaboration into the selected research (all research papers are single-authored) and DC=1 ⟹ All publications are collaboration. (all research papers are more than one authored)

The degree of collaboration is a valuable indicator for examining authorship patterns, inter-disciplinary teamwork, and collaboration trends in scientific research. As shown in Table 5, the degree of collaboration ranged from 0.95 to 0.98 across the study period, with an average of 0.97.

6.5 Authorship Pattern

Table 6: Authorship Pattern

S. No	Authorship Pattern	No of Publications	%
1	Single Author	162	2.56
2	Two Author	2084	32.99
3	Three Author	1782	28.21
4	Four Author	977	15.47
5	Five Author	550	8.71
6	> 5 Author	762	12.06
Total Publications		6317	100

Table 6 shows the authorship pattern in wind energy research publications in India during the selected ten-year study period. It was used for Pradhan [16], Bohra [17]. Out of that, maximum of 2084 (32.99%), research publications are published by two authors, followed by 1782 (28.21%) research publications with three authors. Out of 6317 wind energy research publications in India, 162 (2.56%) publications are single-authored publications. The overall study identified that, 97.44% of publications are in multi-authored publications.

6.6 Collaborated Countries in India

Table 7: Collaborating Countries

S. No	Name of the countries	No of Papers	% of 6317
1	Saudi Arabia	141	2.23
2	United States	97	1.54
3	Malaysia	77	1.22
4	United Kingdom	66	1.04
5	Ethiopia	62	0.98
6	Iraq	51	0.81
7	South Korea	48	0.76
8	China	45	0.71
9	South Africa	44	0.70
10	Australia	41	0.65
11	Other 90 countries	764	12.09
Total		1436	22.73

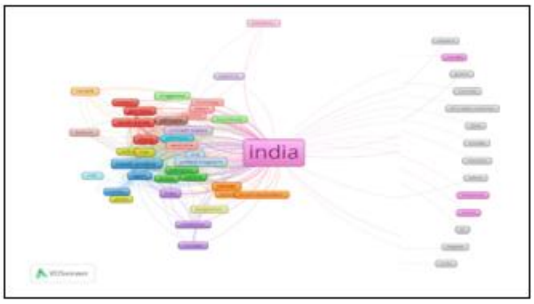

Figure 4: International Collaborating Countries

Table 7 and Figure 4 shows the nation's collaborations in India with a wind energy research publication during the study period. This study identified that a total of 100 countries collaborated with India, and the maximum of 141 (2.23%) publications were collaborated on by Saudi Arabia, followed by the United States with 97 (1.54%) publications. Third place was taken by Malaysia (77) and fourth place by the United Kingdom with 66 publications. The study confirmed that 1436 (22.73%) publications are collaborated on by international authors.

6.7 Keyword Analysis

Keyword Co-occurrence Analysis: Subject keywords are important to classify the core themes and trends; keywords are helping the scientists to understand the main focus areas in existing literature. It was used for Thanuskodi [19]. The frequency analyse of terms in article abstracts provides valuable insights into the present and future directions of wind energy research in India. The word cloud generated from article

Figure 5: Keyword

abstracts, shown in figure 5, reveals the top 50 most frequently identified keywords. The top ten keywords with high frequency, such as wind power (n = 4177) (16%), wind energy (n = 1057) (4%), wind turbines (n = 955) (4%), etc., are the primary research keywords in the field of wind energy research for the selected study period.

6.8 Top 10 Institutions Contribution

Table 8 shows the top 10 institutional contributions to wind energy research publications in India for the selected ten-year study period. It was used for Gonçalves [18] Out of that, the Indian Institute of Technology, New Delhi, India, is the top productive institution with 210 (3.32%) publications, 3575 citations, CPP is 17.02 and h-index is 30, followed by the Vellore Institute of Technology, Chennai, Tamil Nadu, with 192 (3.04%) publications, 3905 citations, CPP is 20.34 and h index is 32, and third place is held by the National Institute of Technology, Kurukshetra, Haryana, with 125 (1.98%) publications, 1522 citations, CPP is 12.18 and h-index is 19. The top ten institutions published 1170(18.52%) publications, 17537 citations and CPP is 14.99.

6.9 Citation Range

Table 9: Citation Range

No of Citations	No of Publications	%
0	1613	25.53
1	890	14.09
2	592	9.37
3	423	6.70
4	360	5.70
5	289	4.57
6	210	3.32
7	179	2.83
8	155	2.45
9	123	1.95
10	107	1.69
Above 10	1376	21.78
Total	6317	100.00

Table 9 shows the citation range of wind energy research publications in India during the 10-year study period with 6317 publications. Out of that 1376(21.78%) publications have the more than 10 citations, 107(1.69%) publications have the ten citations, 123(1.95% publications are having nine citations. During the study period, 1613(25.53%) publications did not have any citations.

6.10 Highly Cited Publications

Table 10: Highly Cited Publications

Top cited document	Citations
Ang T.-Z., et al., (2022). A comprehensive study of renewable energy sources: Classifications, challenges and suggestions. *Energy Strategy Reviews*, 43.	918
Khare V., Nema S. & Baredar P. (2016). Solar-wind hybrid renewable energy system: A review. *Renewable and Sustainable Energy Reviews*, 58.	768
Aasim, Singh S.N. & Mohapatra A. (2019). Repeated wavelet transforms based ARIMA model for very short-term wind speed forecasting. *Renewable Energy,* 136.	587
Kumar D. & Chatterjee K. (2016). A review of conventional and advanced MPPT algorithms for wind energy systems. *Renewable and Sustainable Energy Reviews*, 55.	585
Singh S., Singh M. & Kaushik S.C. (2016). Feasibility study of an islanded microgrid in rural area consisting of PV, wind, biomass and battery energy storage system. *Energy Conversion and Management*, 125.	452
Venkataramani G., et al., (2016). A review on compressed air energy storage – A pathway for smart grid and polygeneration. *Renewable and Sustainable Energy Reviews*, 62.	340
Roga S., et al., (2022). Recent technology and challenges of wind energy generation: A review. *Sustainable Energy Technologies &Assessments*, 52.	326
Jaseena K.U.& Kovoor B.C. (2021). Decomposition-based hybrid wind speed forecasting model using deep bidirectional LSTM networks. *Energy Conversion and Management,* 235.	297
Sahu B.K. (2018). Wind energy developments and policies in China: A short review. *Renewable and Sustainable Energy Reviews*, 81	293
Amjith L.R.& Bavanish B. (2022). A review on biomass and wind as renewable energy for sustainable environment. *Chemosphere*, 293.	264

Table 10 identified, the highest number of 918 citations received by Ang T.-Z., et al. (2022). A comprehensive study of renewable energy sources: Classifications, challenges and suggestions, energy strategy reviews, 43. Followed by 768 citations by Khare V., Nema S. & Baredar P. (2016). Solar-wind hybrid renewable energy system: A review, Renewable and Sustainable Energy Reviews, 58.

7. Major Findings

The study identified 6,317 Indian wind energy publications during 2016–2025. Publication output peaked in 2024, with 942 papers (14.91%), 4,572 citations, and CPP of 4.85. Conference papers were the dominant document type (2,952; 46.73%). Singh, B. (IIT New Delhi) was the most productive author, with 98 publications (1.55%), 1,579 citations, CPP of 16.11, and h-index of 23. The average degree of collaboration was 0.97; two-authored works were the most common pattern (2,084; 32.99%), and 97.44% of all outputs were multi-authored.

India collaborated with 100 countries; Saudi Arabia led with 141 (2.23%) co-authored publications. Wind power was the top keyword (n = 4,177; 16%). IIT New Delhi was the leading institution with 210 (3.32%) publications, 3,575 citations, CPP of 17.02, and h-index of 30. On citation impact,1,376 (21.78%) publications received more than 10 citations while 1,613 (25.53%) remained uncited.

The most highly cited paper was Ang T.-Z. et al. (2022), receiving 918 citations, followed by Khare et. al., (2016) with 768 citations.

8. Conclusion

This scientometric study analysed 6,317 wind energy research publications produced by Indian researchers during 2016-2025 using the Scopus database. The findings reveal steady growth in publication output—consistent with the rapid global expansion of wind energy capacity in recent years [1]- along with strong collaborative research activity and significant institutional contributions from the Indian Institute of Technology, New Delhi, and Vellore Institute of Technology. Conference papers constituted the dominant publication type, while Saudi Arabia emerged as the leading international research partner. Citation analysis indicated substantial research impact, although a considerable proportion of publications remained uncited. Emerging themes such as AI integration in wind energy systems [20], which are currently underrepresented in the literature, present important directions for future research. The study demonstrates the growing importance of India in global wind energy research and provides valuable evidence for future research planning, funding allocation, and international collaboration, in alignment with global clean energy transition goals [3].

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