DOI: 10.63550/ICEIP.2025.90.97.018

A Review of Wind Generator Efficiency and Power Generation in Published Research

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Keywords: The paer search was conducted using the keywords: modelling, wind, generator, efficiency and power, in various combinations, utilizing Boolean operators to refine results. Publication Timeframe: The articles considered were published between 2014 and 2024. Research Focus: Studies that focus on generator, energy efficiency, power and the optimization of wind turbine were included.

Abstract: Wind energy has become an integral part of the global transition to sustainable power system. At the heart of this development is the efficiency and power of wind generators, which directly affects the viability and expansion of wind-based electricity generation. To better understand the advancement in this field a comprehensive analysis of research published from 2014 to 2024 are systematically examined using targeted keyword combination (wind, generator, efficiency, power, and energy) to ensure relevance and specificity. The review also examines trends in the frequency of publications, geographical distribution and leading research institutes leading to the development of wind energy technologies. It also identifies the most frequently addressed topics and emerging areas of interest in the field.

1 INTRODUCTION

Renewable energy's rising relevance, particularly in industrial nations, is predicted to reduce the use of fossil fuels in the energy mix, resulting in lower carbon emission. Using fossil fuels produces emissions, whereas renewable energy sources are often considered to have net-zero carbon footprint. Wind energy is widely available form of renewable energy sources that can be used to generate electricity. Wind energy does not directly produce emissions and thus helps countries meet their emissions reduction goals and solve climate change (Solarin, Bello, 2022). The wind energy industry has gained notable advances in several key sectors, including aerodynamics engineering, mechanical components, electrical generation technologies, and power management system. This field encompasses critical aspects such as power electronic conversion technologies, integration with electrical grids, and control system methodologies. Within wind energy conversion system, electrical generators and power electronics converters play and indispensable role in ensuring operational efficiency and performance (Yaramasu, Wu, Sen, Kouro, Narimani, 2015).

A review of published researches from 2013 to 2024, source from Scopus database, illustrates a rapid advance in scientific studies addressing different aspects of Wind energy, including systems design and efficiency (Hernandez-Estrada, 2021; Firoozi, Hejazi, Firoozi, 2024).

This article offers a detailed review of the published scientific works on wind energy, focusing

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on publication trends, important contributing nations, document types, topic areas, significant organizations, and prominent authors.

2 METHODS

The methodology used in this study involves a systematic review of the published research on improving the efficiency of the generator of wind power plants. The data for this review were collected from the Scopus database, covering the period from 2014 to 2024. The study employs a structured approach to identify relevant research, organize the data, and analyse trends and findings to gain insights into developments in the field depending on the specific key words ‘‘*Wind*’’, ‘‘*Generator*’’, ‘‘*Efficiency*’’, ‘‘*Power”*. Below are the key components of the methodology:

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For a best viewing experience the used font must be Times New Roman, on a Macintosh use the font named times, except on special occasions, such as program code (Section 2.3.8).

Data Screening and Organization: To ensure the quality and relevance of the studies included in the review, the following steps were taken:

Initial Screening: Titles and abstracts of articles were initially reviewed to assess their relevance to the topic of improving the efficiency of the generator of wind power plants.

Full-text Review: Articles passing the initial screening were subjected to a thorough full-text examination to extract detailed information related to modelling techniques, system design, energy analysis, and performance metrics.

Exclusion Criteria: Studies not directly related to improving the efficiency of the generator of wind power plants were excluded, as were those published in languages other than English.

Data Processing and Analysis: The selected studies were analysed using both qualitative and quantitative approaches to identify trends, gaps, and key advancements in the field:

Quantitative Analysis: The number of publications over the selected period (2013–2024) was tracked to identify growth patterns in research interest in improving the efficiency of the generator of wind power plants.

Thematic Analysis: Research articles were categorized based on common themes such as efficiency improvement technique, power output and performance. This allowed for an understanding of the key focus areas and evolution of the research.

Performance Metrics: The studies were also examined to evaluate key performance indicators such as efficiency metrics, power performance indicator, and quality and stability metrics of the wind power plant in different environmental conditions and operational scenarios.

Data Synthesis and Presentation: To present the findings effectively, the data were synthesized and visualized:

Graphical Representation: Trends in the number of publications over time, the distribution of research themes, and the effectiveness of different modelling approaches were visualized using graphs and charts.

Comparison of Techniques: A comparative analysis was conducted to assess the strengths and weaknesses of the efficiency of the generator of wind power plants.

Ensuring Study Quality and Integrity: To ensure the reliability and integrity of the study, the following steps were incorporated:

Cross-referencing: All data extracted from the Scopus database were cross-checked against multiple sources to verify their accuracy and consistency.

Critical Evaluation: Each article was critically evaluated based on its methodology, modelling approach, and relevance to the field of solar tunnel dryers.

Identification of Research Gaps: Gaps in the existing literature were identified, highlighting areas where further research is needed to enhance the efficiency of the generator of wind power plants.

3 RESULTS AND DISCUSSION

A search in the Scopus database using the keywords "*Wind*," "*Generator*," "*Efficiency*," and *"Power"* was conducted to analyse the scope of research in this field. Figure 1 presents the contributions by different countries, demonstrating the global interest and activity in this area of study.

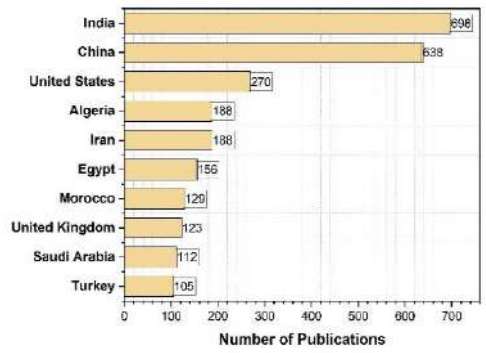

Figure 1: Total number of publications along with the percentage share of each country in these publications from 2014 to 2024.

The visual representation in Figure 1 comprehensive visual analysis is presented on the topic of improving the efficiency of wind power plant generators from 2014 to 2024. The graph above illustrates the number of scientific publications and research efforts carried out globally in the field of energy efficiency and the development of wind energy systems. According to the data, India leads with 698 scientific publications, followed by China with 638 publications over the 2014–2024 period. The United States ranks next with 270 publications, followed by Algeria and Iran with 188 publications each. Although the number of scientific publications in other countries is not as high, research related to energy efficiency and wind energy technologies has still been conducted. Notably, countries such as Egypt, Morocco, the United Kingdom, Saudi Arabia, and Turkey have each produced over 100 scientific publications in this field.

This Figure 2 illustrates the annual distribution of research publications from 2014 to 2024, focusing on a specific field of wind energy or renewable energy. The chart shows a clear upward trend in the number of documents published over the years, indicating growing interest and research activity in this area. The overall trend shows consistent growth in research output over the decade, with a notable acceleration in the last three years (2022–2024). The years 2023 and 2024 mark the highest publication counts, with 456 and 461 documents, respectively, highlighting a peak in research activity.

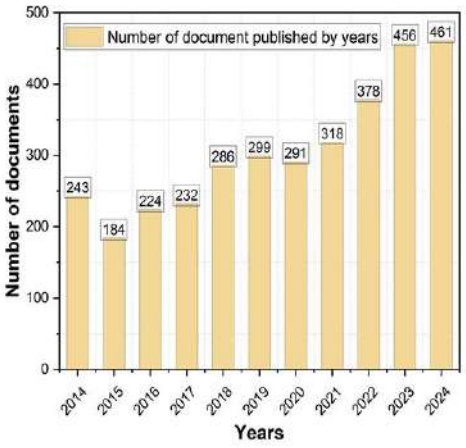

Figure 2: Total number of publications over the years from 2014 to 2024.

Figure 3 presents the annual distribution of research publications from 2014 to 2024 across four prominent sources: Energies, Energy, Renewable Energy, and Appliod Energy. The graph highlights the changes in publication trends among these sources, reflecting their relative contributions to the field of wind energy systems and wind generators.

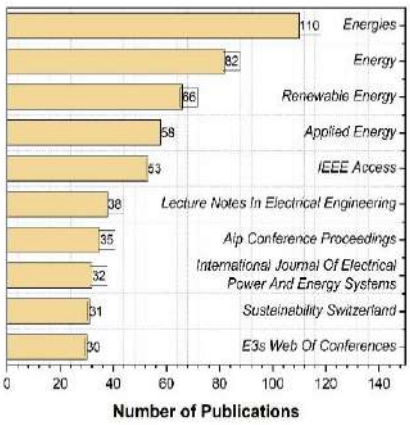

Figure 3: Documents per year by source (2014-2024).

The Figure 3 illustrates the distribution of publications across a range of journals and conference proceedings within the domains of energy and electrical engineering. Energies stands out as the leading publication outlet, with 110 articles, followed by Energy (82 publications) and Renewable Energy (66 publications), indicating a strong emphasis on these platforms for disseminating research. Applied Energy and IEEE Access also show significant contributions, with 58 and 53 publications, respectively. Additional noteworthy sources include Lecture Notes in Electrical Engineering (38), AIP Conference Proceedings (35), and the International

Journal of Electrical Power and Energy Systems (32). The lowest publication counts are observed in Sustainability (Switzerland) and E3S Web of Conferences, with 31 and 30 publications, respectively. Overall, the graph highlights Energies as the primary venue for scholarly output in this field, reflecting its central role in energy –related research dissemination.

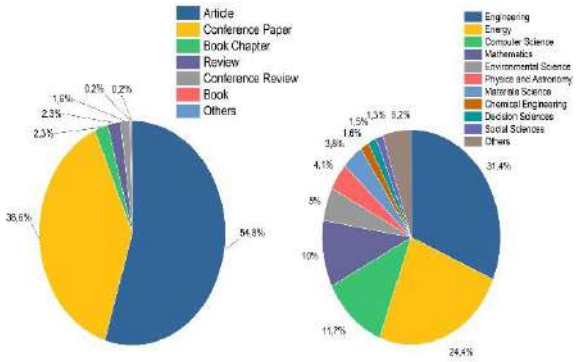

Figure 4: Documents by type and subject area (2014-2024).

Figure 4 illustrates the distribution of publications focused on improving the efficiency of wind power plant generators from 2014 to 2024, categorized by document type and subject area. The chart on the left shows that the majority of these publications are research articles, comprising 54.8% of the total. This is followed by conference papers at 38.6%. Review articles and conference reviews account for smaller proportions—2.3% and 1.6%, respectively. This distribution highlights the dominant role of peer-reviewed journal articles in the dissemination of research findings, while also underlining the importance of conferences as platforms for presenting preliminary results and ongoing investigations.

The chart on the right classifies the publications by subject area, demonstrating the multidisciplinary nature of the field. Engineering constitutes the largest share at 31.4%, followed by energy-related research at 24.4% and computer science at 11.7%. Mathematics also plays a significant role, representing 10% of the publications, which reflects the growing relevance of analytical and computational approaches in optimizing wind energy systems. Additional contributions come from various other fields, including miscellaneous disciplines (5%), physics and astronomy (4.1%), and earth and materials sciences (3.8%). Smaller yet notable contributions are observed from chemical engineering, social sciences, and other areas, indicating the diverse academic engagement in the development of energy-efficient technologies.

This analysis underscores the interdisciplinary scope of research in wind energy efficiency, encompassing core areas such as engineering, energy, mathematics, and computer science, while also drawing on insights from a wide array of scientific and technical disciplines.

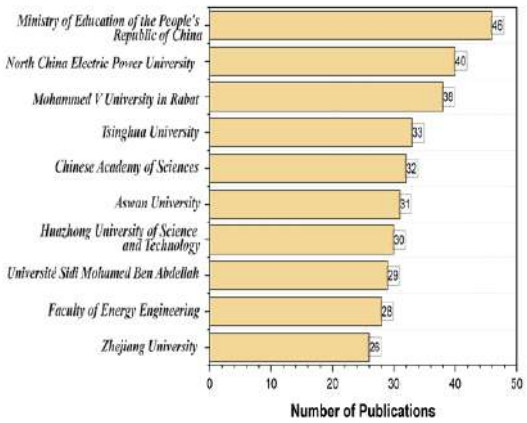

Figure 5: Number of Documents by Institution (2014-2024).

Figure 5 shows that the Ministry of Education of the People's Republic of China leads the research efforts in this field with the highest number of publications, followed by North China Electric Power University. Institutions such as Mohammed University in Rabat, Tsinghua University, and the Chinese Academy of Sciences also make notable contributions. Other contributors include Aswan University, Huazhong University of Science and Technology, Sidi Mohammed Ben Abdellah University, and others. This distribution highlights the significant contributions from universities specializing in agricultural and renewable energy research.

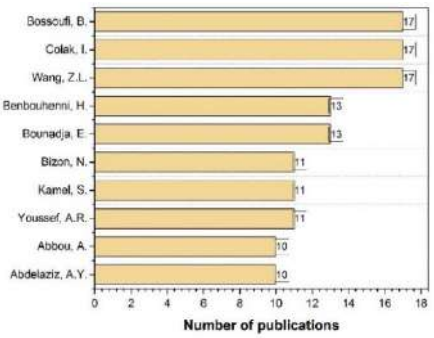

Figure 6: Number of Documents by Authors (2014-2024).

Figure 6 illustrates that Bossoufi, B., Colak, I., and Wang, Z.L are among the most active authors in the field of wind energy, with a significant number of publications. Benbouhenni, H., Bounadja, E., Bizon, N., Kamel, S., Yousset, A.R., Abbou, A., and Abdelaziz, A.Y. also emerge as key contributors. These researchers play a pivotal role in advancing the scientific understanding of wind turbines and wind energy systems.

4 CONCLUSIONS

This review provides a comprehensive analysis of the research landscape on improving the efficiency of wind power plant generators from 2014 to 2024. It examines publication trends, geographical and institutional contributions, document types, subject areas, and key authors. The findings indicate a consistent growth in research interest, with a notable increase in publications in recent years, underscoring the critical role of wind energy technologies in addressing global energy challenges.

India emerges as a leading contributor in terms of research output, reflecting its active involvement in renewable energy and efforts to enhance the efficiency of wind turbines and related systems. Significant contributions have also been made by institutions such as the Ministry of Education of the People's Republic of China and North China Electric Power University. Prominent researchers in the field include B. Bossoufi, I. Colak, and Z.L. Wang, who have made substantial advancements in wind energy technology.

An analysis of document types and subject areas reveals that the majority of publications are scientific articles, primarily focused on energy, renewable energy, wind power, and engineering-related disciplines. Emerging trends, particularly in the integration of wind turbines and wind energy systems into broader energy infrastructures, highlight the dynamic and evolving nature of the field.

By synthesizing these findings, the review not only highlights the contributions of leading countries, institutions, and researchers but also identifies potential directions for future research. These insights aim to support the continued development and implementation of wind energy systems, contributing to global objectives in energy efficiency and sustainability.

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