

# Bibliometric Analysis of Solar and Wind Renewable Energy

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## ABSTRACT

This study conducts a bibliometric analysis of solar and wind renewable energy research to map its intellectual structure, thematic evolution, and global collaboration patterns. Using bibliometric visualization techniques, the study examines keyword co-occurrence, co-authorship networks, institutional collaboration, and country-level research distribution. The findings indicate that the field is strongly centered on core themes such as renewable energy systems, solar energy, and wind power, with significant emphasis on grid integration, optimization, and energy storage technologies. Emerging research trends highlight increasing attention toward hydrogen production, energy transition, sustainability, and policy-driven decarbonization strategies. The collaboration network analysis reveals that China, India, and the United States serve as dominant global research hubs, facilitating extensive international cooperation across Europe, Asia, and the Middle East. Institutional analysis further shows that engineering faculties remain the primary contributors, while interdisciplinary collaboration with economics and management domains is still developing.

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## 1. INTRODUCTION

There are several important transformations occurring at the moment within the global energy industry due to climate change, environmental damage, and exhaustion of fossil fuels [1], [2]. Traditional energy carriers, like coal, oil, and natural gas have been the main drivers of economic development for a long time; however, they have played an essential part in contributing to greenhouse gas emissions and global warming [3]. According to the International Energy Agency, the energy sector is responsible for a considerable part of carbon dioxide emissions on Earth, which means that

the transition to more environmentally-friendly and sustainable energy systems is a matter of great importance [4]. This is why different organizations around the world try to implement new technologies in order to provide energy solutions in a more environmentally-friendly way. The most developed and widely used forms of renewable energy are solar and wind energy because of their prevalence, technology maturity, and cost-effectiveness [5].

Solar energy has seen tremendous growth over the last two decades owing to developments in PV technologies, increasing energy efficiency, and favorable policy

support systems. Reductions in the cost of solar PV panels have greatly enhanced the competitive position of solar energy relative to traditional energy sources. Likewise, wind energy has become an essential source for renewable energy generation due to advancements in the development of turbines, offshore wind farms, and grid technology [6]. Recent studies reveal that solar and wind power combined constitute the highest proportion of newly installed renewable energy capacity in the world, making them key players in the process of reaching carbon neutrality and sustainable development objectives [7].

Increasing relevance of solar and wind energy sources has resulted in a significant rise in the number of scholarly papers written on the topic in a variety of academic disciplines such as engineering, environmental studies, economics, public policy, and energy management. Researchers have examined a wide range of aspects of renewable energy production, from innovations to energy storage, smart grids, economics, environment, energy policy, and social acceptability. Interdisciplinary nature of research on renewable energy technologies has led to the emergence of a complex set of knowledge that is rapidly expanding. Therefore, it has become necessary to understand the structure of knowledge and the dynamics of research on the topic [8].

In the past few years, bibliometrics have been found as an important methodology for the systematic analysis of scientific literature and studying the growth of knowledge in a specific research area. With the help of bibliometrics methods, researchers can study patterns of publications, networks of citations, collaboration among authors, institutions, and connections between research topics. Using special software like VOSviewer, CiteSpace, and Bibliometrix, the findings of a bibliometric analysis could shed light on influential publications, leading countries, clusters of research, and new topics shaping the future of a scientific field [8]. In contrast to conventional literature review, bibliometric analysis offers quantitative and

graphical insights about the process of scholarly communication.

Even though there are many studies done on the independent use of solar energy and wind energy, the overall research on solar energy and wind energy is still fragmental and constantly developing. The converging trends in the usage of solar energy and wind energy in hybrid renewable energy systems and energy transition and decarbonization policies have generated new areas of interest that need to be systematically analyzed. Moreover, the exponential increase in scientific production in this domain creates challenges to researchers trying to identify key topics, influential authors, and collaboration trends using traditional literature reviews. Therefore, carrying out the bibliometric analysis of solar and wind renewable energy research becomes an imperative.

Although the body of research in the field of solar and wind renewable energies has experienced significant growth, the current state of the research is still dispersed across different fields of science, which makes it difficult to understand the structure of the intellectual evolution of this field. Previous researches have mostly concentrated on the technology advancement aspects, policy implication issues, and economic evaluation of renewable energy systems. However, very little attention has been paid to conducting systematic bibliometric mapping of the entire research field. Thus, there is an absence of knowledge regarding publication dynamics, key players, research collaborations, research topics and new areas in the field of solar and wind renewable energies. It means that there is a necessity to conduct a bibliometric investigation that would be able to synthesize existing scientific knowledge and provide strategic recommendations for further research development. The purpose of this paper is to conduct a comprehensive bibliometric analysis of research in the field of solar and wind renewable energies through the examination of publication dynamics, citation dynamics, key researchers and institutions, countries, collaborations and research themes.







renewable technologies. The spatial gradient from yellow to blue demonstrates a clear decline in thematic intensity as topics become more specialized or peripheral.

Peripheral zones (dark green to blue) represent less frequently connected or more specialized research themes, including controllers, smart grids, stochastic systems, electric load dispatching, and power quality. These areas reflect niche but technically

important subdomains, primarily associated with grid stability and advanced energy management. On the policy and sustainability side, terms such as energy policy, carbon, investments, hydrogen production, and energy transition appear moderately dense, indicating growing but still secondary emphasis compared to core generation and system optimization topics.

### 3.2 Citation Analysis

Table 1. Top Cited Documents

Citations	Authors and Year	Title
9325	[9]	The Li-ion rechargeable battery: A perspective
4957	[10]	A comprehensive review on PEM water electrolysis
4439	[11]	The role of renewable energy in the global energy transformation
3854	[12]	Power-electronic systems for the grid integration of renewable energy sources: A survey
3483	[13]	Role of renewable energy sources in environmental protection: A review
2920	[14]	A comparative overview of hydrogen production processes
2779	[6]	Renewable energy resources: Current status, future prospects and their enabling technology
2620	[15]	Challenges facing lithium batteries and electrical double-layer capacitors
2405	[16]	Power electronics as efficient interface in dispersed power generation systems
2303	[17]	Challenges and prospects of lithium-sulfur batteries

Source: Scopus, 2026

### 3.3 Co-Authorship Analysis

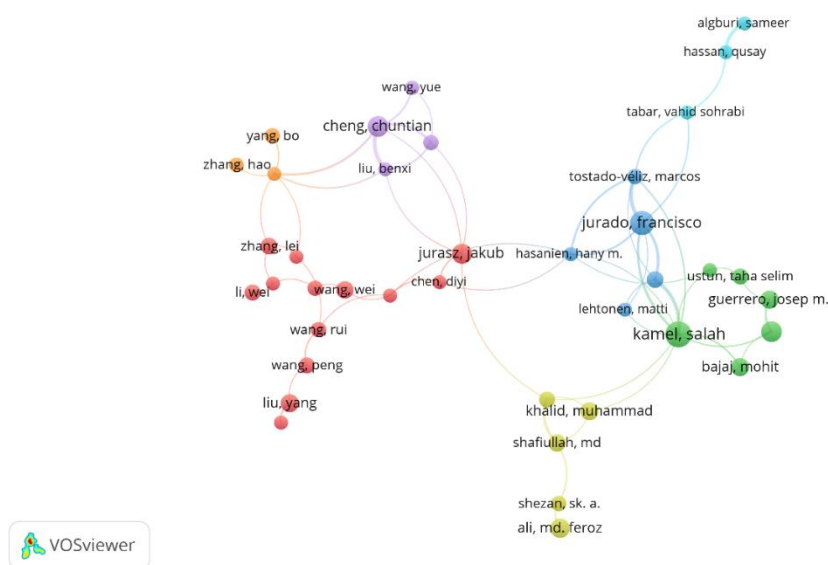


Figure 4. Author Visualization

Source: Data Analysis, 2026

Figure 4 reveals a fragmented but structured research collaboration landscape divided into several distinct clusters. On the left side, a red and orange cluster is dominated by Chinese authors such as Wang Wei, Zhang Lei, Liu Yang, and Chen Diyi, indicating a relatively dense intra-country collaboration network with strong internal connectivity but limited external linkage. In the center, bridging nodes such as Jurasz Jakub and Cheng Chuntian act as intermediaries connecting multiple clusters, suggesting their role as key contributors in linking different research groups or thematic

communities. On the right side, a blue–green cluster is formed by researchers such as Francisco Jurado, Salah Kamel, Mohit Bajaj, and Josep M. Guerrero, which is strongly interconnected and reflects a more internationally distributed collaboration pattern in renewable energy systems research. Additional peripheral clusters, including scholars like Khalid Muhammad and Md. Feroz Ali, indicate emerging or smaller research groups that connect weakly to the main network but still contribute to cross-regional knowledge exchange.

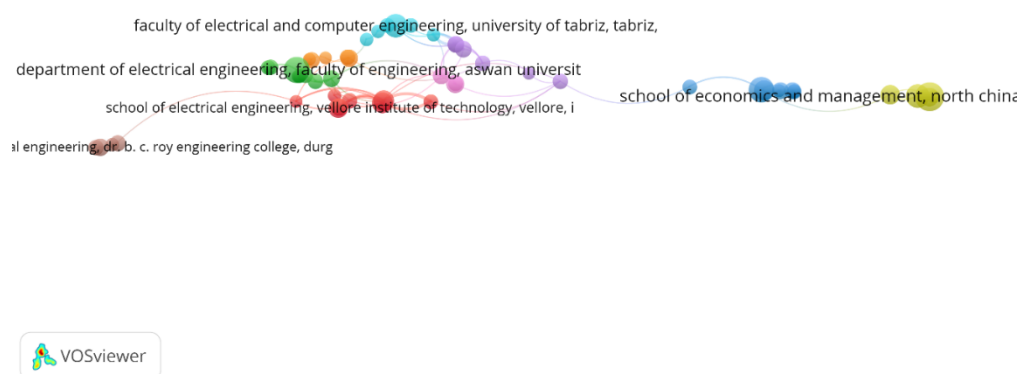


Figure 5. Institution Visualization

Source: *Data Analysis, 2026*

Figure 5 represents an institutional co-authorship network in renewable energy research, showing a clearly segmented collaboration structure across universities and disciplines. On the left and central region, most nodes are dominated by electrical and computer engineering institutions such as the School of Electrical Engineering at Vellore Institute of Technology, the Department of Electrical Engineering (various affiliations), Dr. B.C. Roy Engineering College, and the Faculty of Engineering at Aswan University and University of Tabriz. These institutions form a tightly connected cluster, indicating

strong intra-disciplinary collaboration within electrical engineering–focused renewable energy research, particularly in technical domains such as power systems and energy optimization. On the right side, a distinct cluster is formed by the School of Economics and Management at North China University, which is relatively separated from the engineering-heavy group but connected through a few bridging links. This indicates an interdisciplinary but still limited integration between technical engineering research and socio-economic or policy-oriented studies in renewable energy.

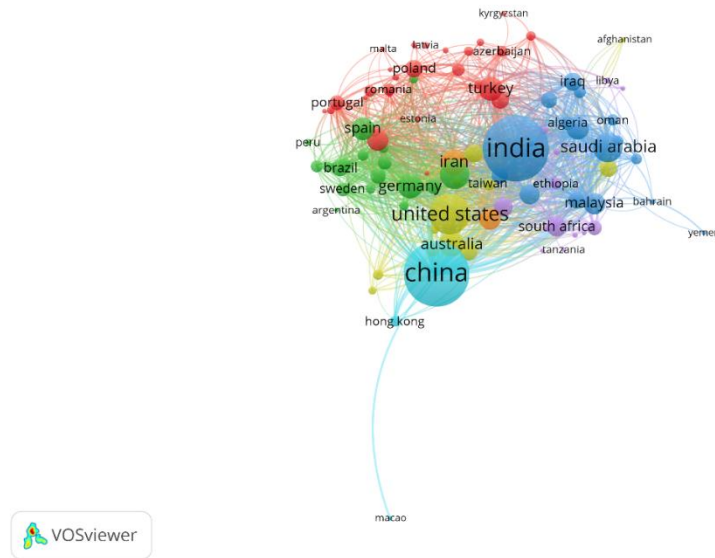


Figure 6. Country Visualization

Source: Data Analysis, 2026

Figure 6 presents a country-level collaboration network in renewable energy research, where node size reflects publication influence and link density indicates international cooperation strength. China, India, and the United States emerge as the dominant hubs, with China and India particularly central and highly connected, suggesting they function as primary production centers and collaboration intermediaries in the global research ecosystem. The United States also shows strong connectivity across multiple regions, indicating its role as a major bridging node between Asian, European, and Middle Eastern research clusters. Surrounding these core countries are several regional collaboration groups. European countries such as Germany, Spain, Portugal, Sweden, and Poland form a relatively cohesive cluster with dense intra-regional links, reflecting strong EU-based research integration. Meanwhile, Middle Eastern and North African countries such as Saudi Arabia, Iran, Algeria, Iraq, and Oman form another interconnected group, often linking through India and China rather than directly with Western Europe. Smaller or peripheral nodes such as Afghanistan, Yemen, and Macau indicate limited participation and weaker

integration into the global collaboration structure.

#### 4. CONCLUSION

This bibliometric study of solar and wind renewable energy research reveals a rapidly expanding and increasingly integrated global knowledge structure. The analysis shows that the field is strongly centered on the intersection of solar energy, wind power, and renewable energy systems, with technical studies on grid integration, optimization, and energy storage forming the foundational core. At the same time, emerging thematic directions such as hydrogen production, energy transition, sustainability, and energy policy indicate a clear shift toward system-wide decarbonization and interdisciplinary energy transition research.

The collaboration and institutional analyses further demonstrate that renewable energy research is dominated by a small number of leading countries—particularly China, India, and the United States—which function as global hubs of scientific production and collaboration. European countries maintain strong regional cohesion, while developing regions remain more peripheral but increasingly connected through major research hubs. At the

institutional level, collaboration is still largely concentrated within engineering-focused faculties, with limited but growing

integration of economics and policy-oriented institutions.

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