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Scientometric Analysis of Renewable Energy Investment: Examination of Patterns and Key Topics

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ABSTRACT

This study conducts a scientometric analysis of renewable energy investment (REI) with the aim of identifying major patterns and key thematic areas within this field. Given the growing importance of renewable energy in addressing environmental challenges and achieving sustainable development, the research investigates scientific trends related to investment in renewable energy. The research adopts a descriptive design and utilizes data indexed in the Scopus database covering the period from 2000 to 2025. A systematic search strategy was implemented to retrieve relevant publications, including the identification of appropriate keywords, their combination using Boolean operators, and a rigorous screening process of the retrieved documents. Ultimately, 1,123 articles were selected as the final statistical population. The findings indicate a significant increase in the number of publications over the past two decades, with China and the United States emerging as leading contributors in this domain. Keyword co-occurrence analysis revealed that concepts such as "investment," "renewable energy," "energy policy," and "sustainable development" hold central positions and are frequently addressed in the scientific literature. The study also emphasizes the importance of institutional and policy interactions in renewable energy investments and provides a foundation for future research in this field. In particular, the results can assist researchers, policymakers, and investors in developing more effective strategies for sustainable development and renewable energy investment by improving understanding of prevailing trends and existing challenges.

Keywords: Renewable Energy Investment, Scientometrics, Energy Policy, Sustainable Development, Network Analysis

Introduction

The transition toward renewable energy has emerged as one of the most significant structural transformations of the global economy in the twenty-first century. Increasing environmental pressures, climate change risks, and growing energy demand have compelled governments, investors, and international institutions to reconsider traditional fossil fuel–based development models and accelerate investment in renewable energy systems. Renewable energy investment is no longer viewed solely as an environmental necessity; rather, it represents a multidimensional economic, technological, and geopolitical strategy shaping sustainable growth trajectories worldwide. The global expansion of renewable energy deployment reflects a convergence of environmental sustainability objectives, economic diversification goals, and long-term energy security considerations (1, 2).

Renewable energy investments play a central role in reducing greenhouse gas emissions while supporting economic resilience and innovation-led development. International assessments indicate that financial flows toward

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renewable infrastructure have increased substantially as countries seek to achieve carbon neutrality and sustainable development targets. These investments stimulate technological innovation, create employment opportunities, and enhance national competitiveness within emerging green economies (1). Empirical studies demonstrate that renewable energy deployment is strongly influenced by financial accessibility, institutional stability, and policy frameworks designed to reduce investment uncertainty and enhance market attractiveness (2). Consequently, renewable energy investment has become a critical driver linking environmental policy with economic modernization.

The evolution of renewable energy systems cannot be separated from broader transformations in global energy governance and international relations. Energy transition processes influence geopolitical balances by reducing dependence on fossil fuel exporters and redistributing technological leadership among nations investing in clean energy innovation. The shift from fossil-based energy systems toward renewable alternatives contributes not only to emission reduction but also to restructuring international economic relations and strategic alliances (3). Countries investing heavily in renewable energy infrastructure are increasingly positioned as leaders in the emerging low-carbon global order, highlighting the strategic importance of renewable investment decisions.

From an innovation perspective, renewable energy technologies represent complex socio-technical systems requiring coordination between technological advancement, organizational adaptation, and policy support mechanisms. Early socio-technical theory emphasized that technological transformation succeeds when organizational structures, human resources, and technological systems evolve simultaneously (4). Renewable energy investment exemplifies this interaction, where technological feasibility alone is insufficient without supportive institutional arrangements and financing models. Innovation-focused energy policies accelerate technology diffusion and enable renewable systems to penetrate traditional energy markets (5). Such diffusion processes depend heavily on coordinated investment strategies that integrate economic incentives, regulatory frameworks, and technological learning curves.

Financial mechanisms constitute another fundamental dimension shaping renewable energy investment dynamics. Access to capital, risk management strategies, and financing structures significantly determine the viability of renewable projects. Studies on renewable energy financing emphasize the importance of diversified funding channels, including private investment, public subsidies, and blended finance approaches to support large-scale deployment (6). The growing integration of green finance instruments and government expenditures further strengthens sustainable development outcomes by aligning financial markets with environmental objectives (7). Investments in renewable energy therefore operate at the intersection of finance, environmental psychology, and policy design, illustrating the interdisciplinary nature of energy transition research.

Risk assessment has become a decisive factor influencing investment behavior in renewable energy markets. Investors must consider technological uncertainty, policy instability, market volatility, and long-term revenue risks when allocating capital to renewable projects. Research employing real options approaches demonstrates that economic risk evaluation significantly affects wind farm investments and renewable infrastructure planning (8). Similarly, recent analyses of energy transition dynamics reveal interconnected risks between fossil fuel markets and renewable energy systems, emphasizing the importance of understanding downside risks and systemic interdependencies within energy markets (9). These findings underline the necessity of evidence-based investment strategies capable of balancing financial returns with sustainability objectives.

Public–private cooperation has also emerged as a crucial mechanism facilitating renewable energy investment expansion. Collaborative investment arrangements enable governments and private actors to share risks, mobilize resources, and accelerate technological adoption. Evidence from emerging economies indicates that public–private partnerships significantly contribute to renewable energy growth, particularly when supported by political cooperation and stable institutional environments (10). Such partnerships enhance infrastructure development while encouraging innovation and market expansion, reinforcing the role of governance structures in shaping renewable energy investment outcomes.

At the operational level, renewable energy investment increasingly focuses on optimizing resource management and improving energy efficiency across sectors. Integrated resource strategic planning demonstrates how renewable energy adoption can enhance efficiency within power systems while reducing operational costs and environmental impacts (11). Sector-specific applications further illustrate this trend; for example, renewable energy management strategies in sports complexes and large facilities highlight the economic and environmental benefits of optimized energy systems (12). These examples show that renewable investment extends beyond national energy policy and influences organizational energy management practices.

Technological diversification within renewable energy systems has further expanded investment opportunities. Solar photovoltaic systems, wind energy installations, and biogas projects increasingly demonstrate techno-economic feasibility across different geographic contexts. Case studies assessing rooftop solar photovoltaic systems confirm that renewable technologies can provide adaptable pathways toward net-zero carbon transitions when evaluated through integrated techno-economic and environmental frameworks (13). Similarly, demand-driven investment models in agricultural biogas plants illustrate how renewable energy investments can simultaneously enhance energy security and economic sustainability in rural production systems (14). These developments highlight the growing maturity and scalability of renewable technologies as investment assets.

Beyond technological and financial considerations, behavioral and psychological dimensions also influence renewable energy investment and adoption. Environmental psychology research indicates that societal attitudes, awareness, and governmental spending patterns significantly shape sustainable development outcomes. Green finance initiatives combined with public environmental consciousness create favorable conditions for renewable energy expansion (7). Investment decisions are therefore embedded within broader social contexts where public perception, environmental responsibility, and policy legitimacy interact to shape energy transition trajectories.

The globalization of renewable energy investment further underscores the importance of cross-sectoral and interdisciplinary approaches. Sustainable financing models originally developed for sectors such as maritime tourism demonstrate how financial innovation can support environmentally responsible economic activities across diverse industries (15). Such approaches illustrate the transferability of sustainable investment frameworks and reinforce the necessity of integrating environmental, economic, and institutional perspectives in renewable energy research.

Given the rapid expansion of scientific literature addressing renewable energy investment, systematic synthesis and mapping of research trends have become increasingly essential. The growth of academic publications requires structured methodological frameworks capable of organizing knowledge and identifying emerging research frontiers. Reporting standards such as the PRISMA guidelines provide rigorous procedures for systematic reviews, ensuring transparency, replicability, and methodological consistency in scientific synthesis (16). Scientometric

approaches build upon these principles by enabling large-scale analysis of publication patterns, collaboration networks, and thematic evolution within research domains.

Recent empirical evidence emphasizes that renewable energy investment contributes not only to energy consumption transformation but also to environmental sustainability and human capital development. Studies examining oil-rich regions demonstrate that investment in renewable infrastructure, combined with human capital development, significantly enhances renewable energy consumption and environmental performance (17). Such findings highlight the strategic importance of investment policies that integrate infrastructure development, technological capacity building, and sustainability objectives.

Despite substantial progress, renewable energy investment research remains fragmented across disciplines including economics, environmental science, policy studies, and management. Scholars continue to debate the relative importance of financial incentives, technological innovation, institutional governance, and social acceptance in driving renewable deployment. The expanding complexity of energy transition processes requires comprehensive analytical frameworks capable of synthesizing diverse research perspectives and identifying dominant themes within the literature (2, 3). Scientometric analysis offers a powerful methodological tool for addressing this challenge by quantitatively mapping scientific production and revealing intellectual structures shaping the field.

Furthermore, understanding global research patterns provides valuable guidance for policymakers and investors seeking evidence-based decision-making tools. Identifying leading countries, influential journals, collaboration networks, and emerging research topics enables stakeholders to allocate resources more efficiently and anticipate future investment trends. As renewable energy markets evolve under conditions of technological innovation, climate urgency, and financial transformation, systematic knowledge mapping becomes indispensable for supporting sustainable policy design and strategic investment planning (1, 9).

In summary, renewable energy investment represents a critical nexus connecting environmental sustainability, technological innovation, financial systems, and global governance. The increasing volume of research in this domain reflects the growing recognition that energy transition requires coordinated action across economic, institutional, and societal dimensions. However, the rapid expansion of scholarly output necessitates comprehensive scientometric evaluation to clarify research trajectories, dominant themes, and knowledge gaps within the field. Accordingly, the aim of this study is to conduct a scientometric analysis of renewable energy investment research in order to identify major research patterns, thematic trends, and intellectual structures shaping this evolving field.

Methods and Materials

The present study conducts a scientometric analysis of renewable energy investment and was carried out with an applied objective using a descriptive research design. The research adopts a scientometric approach, and its statistical population consists of studies related to renewable energy investment indexed in the Scopus database during the period from 2000 to 2025. A systematic and targeted search strategy was employed to identify relevant publications, including the following stages:

1. **Identification of Keywords:** Initially, keywords relevant to the research topic were identified and selected. These keywords included:
    - Renewable Energy Investment
    - Solar Energy

- Wind Energy
- Geothermal Energy
- Energy Policy
- Sustainable Development
- Climate Change
- Innovative Technologies
- Green Financing

2. **Combination of Keywords Using Boolean Operators:** The Boolean operator OR was used to combine related keywords in order to identify articles addressing any of these topics. For example:
   • “Renewable Energy Investment” OR “Solar Energy” OR “Wind Energy” OR “Geothermal Energy” OR “Energy Policy” OR “Sustainable Development” OR “Climate Change” OR “Innovative Technologies” OR “Green Financing”
3. **Use of the AND Operator:** The AND operator was applied to restrict the search to studies simultaneously addressing multiple related topics. For example:
   • (“Renewable Energy Investment” AND “Sustainable Development”) OR (“Solar Energy” AND “Green Financing”) OR (“Wind Energy” AND “Energy Policy”)
4. **Database Search:** The identified keywords and combinations were searched within the Scopus database, considering the time span from 2000 to 2025.

Following the search process, the identified articles were carefully screened to ensure relevance to the research topic, and ultimately 1,123 articles were selected as the final statistical population. At this stage, only original research articles were included in the analysis, while review papers and editorials—which typically do not provide deep and systematic empirical investigations—were excluded. This decision was made to focus on primary empirical studies that contribute to a clearer understanding of trends and innovations in renewable energy investment.

To construct the thematic network and identify relationships among research topics and trends, the VOSviewer software was employed, enabling scientometric analysis and visualization of research networks. During the process of importing publications into VOSviewer, the collected data were reviewed multiple times by the research team to ensure accuracy and reliability and to minimize identification errors. This process involved re-examining article titles, abstracts, and full texts to ensure that all documents were accurately positioned within the thematic network and reflected the actual state of research in this field.

In this study, articles containing sufficient information to address the research questions were selected, including both quantitative and qualitative studies. These publications examined variables related to scientometric analysis and knowledge mapping in renewable energy investment and contributed to identifying effective patterns and strategies within this domain.

Findings and Results

Over the past two decades, studies related to renewable energy investment have increased significantly. This trend is particularly observable across five-year intervals (Figure 1). During the period 2000–2004, a total of 100 articles were published in this field, reflecting the initial emergence of scholarly attention toward renewable energy and its potential contribution to sustainable development. With increasing global awareness of climate change and

the need for sustainable energy resources, the number of publications rose to 150 during the period 2005–2009, indicating growing interest in research and development in this area.

Between 2010 and 2014, the number of publications increased to 250 articles, clearly demonstrating heightened attention from researchers and investors toward technological innovation and supportive policies in renewable energy. Furthermore, during the period 2015–2019, the number of publications reached 300, representing a peak of interest among researchers and decision-makers. This growth was largely driven by the need for deeper analyses concerning the economic and social impacts of renewable energy investment, as well as emerging challenges within the sector. Finally, during the period 2020–2024, a total of 323 articles were published, indicating the continuation of an upward research trajectory. These studies examined innovative strategies, financial policies, and environmental impacts associated with renewable energy investment, contributing to a more comprehensive understanding of existing opportunities and challenges. Overall, these trends demonstrate the increasing importance of renewable energy in sustainable development and highlight the necessity of continued investment in this sector.

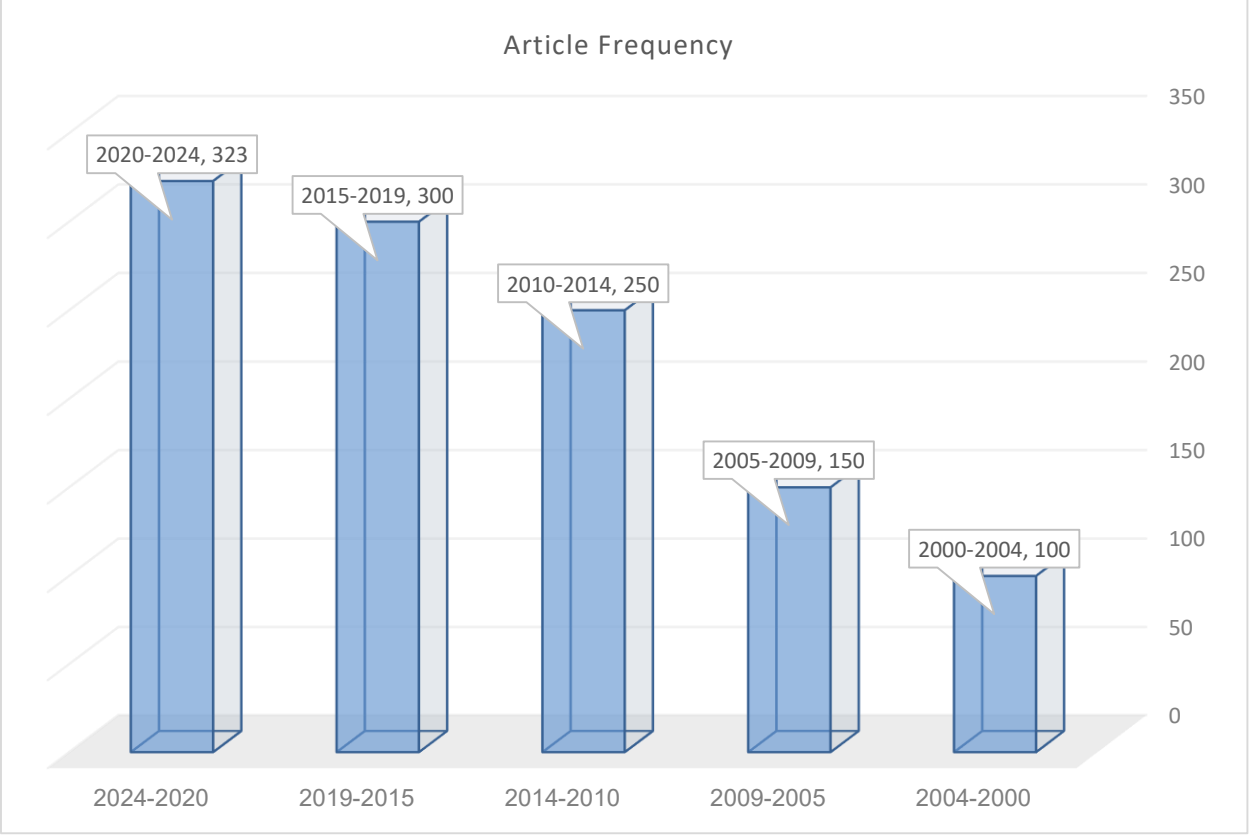

Figure 1. Trend of Publications on Renewable Energy Investment

Based on the results presented in **Table 1**, China ranks first as the leading country in scientific production related to renewable energy investment, with 162 publications and 5,006 citations. This finding reflects China's strong commitment to research and development in this field, particularly aligned with sustainable energy policies and efforts to reduce dependence on fossil fuels.

The United States ranks second with 148 publications and 4,206 citations. As one of the world's largest energy consumers, the United States has continuously invested in renewable energy technologies as well as research and development activities in this sector.

The United Kingdom ranks third with 82 publications and 2,525 citations. Owing to strong national policies addressing climate change and renewable energy transition, the country has made substantial scientific contributions to this research domain.

Poland and Iran rank fourth and fifth with 60 and 56 publications, respectively. This indicates that developing countries are increasingly recognizing the importance of renewable energy and are strengthening their research activities in this area.

Turkey, Germany, and Pakistan also demonstrate considerable publication outputs, reflecting the expansion of renewable energy research. These countries have shown notable activity particularly in specialized areas such as solar and wind energy technologies.

Finally, countries such as India, Italy, and Spain contribute significantly to global scientific advancement in renewable energy investment through their scholarly outputs. Overall, these data highlight the growing global importance of renewable energy investment and emphasize the necessity of international collaboration to achieve sustainable development goals.

Table 1. Leading Countries in Scientific Production on Renewable Energy Investment

Country	Documents	Citations
China	162	5006
United States	148	4206
United Kingdom	82	2525
Poland	60	738
Iran	56	918
Turkey	50	1703
Germany	50	1767
Pakistan	49	2064
India	47	1177
Italy	41	969
Spain	41	1190
Canada	35	785
Saudi Arabia	35	1004
Netherlands	32	1460
Brazil	28	544
South Korea	27	489
Australia	27	672
Norway	27	728
Denmark	27	965
Russian Federation	26	475

Figure 2 illustrates a network of leading countries contributing to scientific production in renewable energy investment research. The network is constructed using nodes, each representing a country, where node size and color variations indicate clusters or levels of research activity. Within this network, the “United States” clearly occupies a central position, demonstrating its dominant and extensive role in renewable energy investment research. This centrality indicates the country’s key function in knowledge production, research leadership, and the facilitation of international collaboration.

Other countries appear as connection hubs or secondary research centers across specialized domains of renewable energy investment. For instance, countries such as China, India, Germany, France, and the United Kingdom—represented through varying node colors and densities—demonstrate strong participation in specific research areas and international scientific cooperation networks related to renewable energy investment.

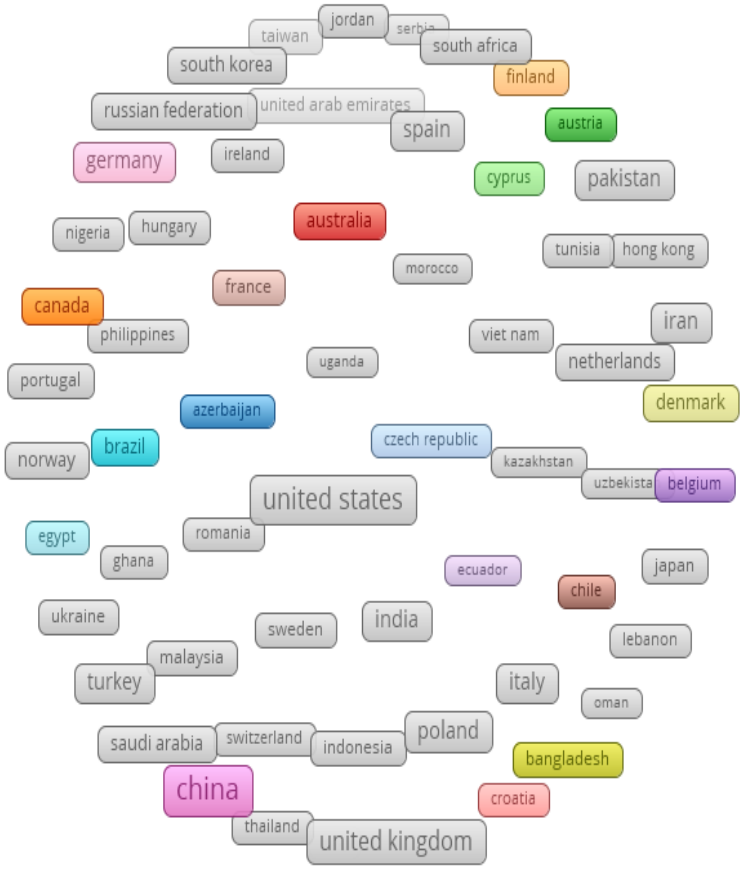

Figure 2. Network of Leading Countries in Scientific Production on Renewable Energy Investment

Table 2 presents leading scientific sources in the field of renewable energy investment. The journal *Energy Policy*, with 49 publications and 2,401 citations, is identified as the most influential source in this domain. This journal focuses on energy strategies and policymaking and plays a significant role in shaping sustainable energy policies.

The journal *Renewable Energy*, with 43 publications and 1,956 citations, represents another key source, particularly emphasizing technological innovation and advancements in renewable energy systems. Additionally, *Energies*, with 69 publications, has the highest number of documents among the listed sources, reflecting strong research concentration in this journal.

Other prominent journals include *Applied Energy* and *Journal of Cleaner Production*, both addressing practical applications of renewable energy and associated environmental impacts. The journal *Sustainability (Switzerland)*, with 41 publications, explores multiple dimensions of sustainable development and its linkage with renewable energy investment.

Furthermore, journals such as *Energy Economics* and *Climate Policy* focus on economic analysis and policy frameworks related to climate change and renewable energy transitions.

Overall, the diversity and high volume of publications across these journals demonstrate the increasing importance of renewable energy investment research and its contribution to sustainable development. These

scientific sources provide researchers and policymakers with reliable empirical evidence and analytical insights to support informed decision-making and improved energy policy formulation.

Table 2. Key Scientific Sources in Renewable Energy Investment Research

Source	Documents	Citations
Energy Policy	49	2401
Renewable Energy	43	1956
Energy	27	1148
Energies	69	953
Applied Energy	23	910
Renewable and Sustainable Energy …	16	834
Journal of Cleaner Production	19	794
Sustainability (Switzerland)	41	758
Environmental Science and Pollution …	36	755
Resources Policy	17	676
Energy Economics	21	450
Journal of Environmental Management	6	361
Climate Policy	7	332
Energy for Sustainable Development	13	291
International Journal of Hydrogen Energy	9	262
Energy Conversion and Management	6	235
International Journal of Electrical Power	7	212
Journal of Energy Storage	11	172
Energy Reports	9	143
Frontiers in Environmental Science	6	140

Table 3 presents the most frequently occurring keywords in the field of renewable energy investment, reflecting key themes and significant conceptual relationships within this research domain. The keyword “investments”, with 267 occurrences and a total link strength of 2,470, clearly indicates the central importance of investment activities in the development and expansion of renewable energy systems. Likewise, the terms “alternative energy” and “renewable energies,” with 240 and 219 occurrences respectively, emphasize scholarly attention toward clean and sustainable energy resources.

Additionally, keywords such as “energy policy” and “renewable energy resources,” both with high occurrence frequencies, highlight the necessity of establishing effective and sustainable policy frameworks in this area. The keyword “sustainable development,” appearing 117 times, reflects increasing attention to the economic, social, and environmental dimensions embedded in renewable energy investment processes.

Another group of keywords relates to climate change and carbon dioxide, illustrating global pressures to mitigate the adverse effects of fossil fuel consumption and climate-related challenges. These concepts have gained particular relevance in light of growing international concern regarding environmental protection and greenhouse gas emission reduction.

Overall, the diversity and frequency of keywords reported in the table demonstrate the multidimensional and complex nature of renewable energy investment research. These findings provide researchers, policymakers, and investors with deeper insight into prevailing trends, research priorities, and emerging challenges in this field.

Table 3. Most Frequent Keywords in the Renewable Energy Investment Network

Keyword	Occurrences	Total Link Strength
Investments	267	2470
Alternative Energy	240	2146
Renewable Energies	219	1889
Energy Policy	179	1702
Renewable Energy Resources	179	1531
Sustainable Development	117	1185
Investment	111	1102
Carbon Dioxide	105	1111
Renewable Energy Source	102	1067
Energy Efficiency	93	814
Wind Power	92	739
Climate Change	91	847
Renewable Energy Source	90	769
Economy	88	940
Costs	84	883
Carbon Emissions	78	849
Renewable Energy	76	747
Fossil Fuels	68	675
Energy Use	63	687
Carbon	63	679
Commerce	63	608
Energy	63	475
Emission Control	61	610
Sustainability	54	548
Economic Development	51	560
Greenhouse Gases	51	558
Economic Analysis	50	500
Power Generation	49	538
Decision Making	49	443
Energy Market	48	498
Power Generation	47	454
Solar Energy	47	402
Energy Transition	46	415
China	45	475
Gas Emissions	43	509
Energy Source	43	452
Solar Power Generation	43	404
Electric Utilities	43	368
Environmental Economics	42	410
Economic Growth	41	470

Figure 3 illustrates an extensive keyword network related to renewable energy investment. The main nodes represent key concepts, while node size and color indicate conceptual weight and thematic clustering. Different colored clusters visualize the interconnections among central concepts associated with investment activities, forming a structured knowledge network.

At the center of the network, core keywords such as “investments” and “renewable energy” appear prominently larger and brighter, demonstrating their dominant position in academic research and policy–economic discussions related to clean energy. From these central nodes, additional keywords—including “economic analysis,” “costs,” “energy policy,” “risk assessment,” and “finance”—extend outward, indicating that capital allocation, economic evaluation, and policymaking constitute the primary decision-making mechanisms within renewable energy investment.

Distinct color clusters represent aligned thematic research areas:

• Red Cluster: Keywords related to costs, capital expenditures, energy production, and cost–benefit modeling (e.g., *costs*, *economic analysis*, *solar power*, *wind power*).

• Blue Cluster: Keywords associated with investment dynamics and financial markets, financing instruments, and risk management (e.g., *investments*, *finance*, *risk assessment*, *markets*).

• Green Cluster: Keywords related to policymaking, green economy principles, sustainable development, and environmental–economic dimensions of energy development (e.g., *economic development*, *environmental protection*, *policy*).

• Yellow/Orange Cluster: Keywords connected to renewable energy technologies and infrastructure, including specific technologies such as *solar*, *wind*, *storage*, and infrastructure-related concepts.

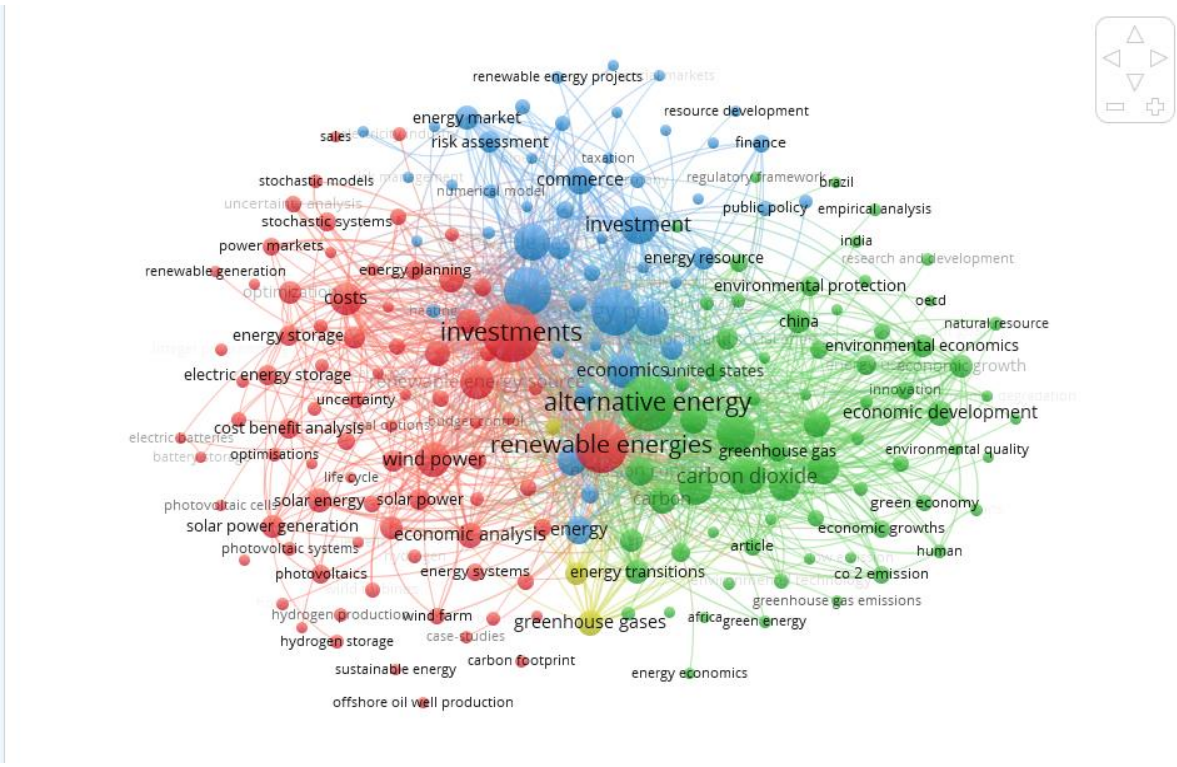

Figure 3. Keyword Network of Renewable Energy Investment

The relationships among clusters demonstrate how financial and economic concepts interact with policy frameworks and technological innovation. Highly connected nodes located near the network core indicate substantial conceptual overlap within renewable energy investment research. Intermediary nodes such as “economic analysis” or “cost–benefit analysis” function as bridging mechanisms linking the red cluster (cost and economic evaluation) with the green cluster (policy and environmental–economic development). This co-occurrence structure suggests that renewable energy investment research primarily focuses on economic optimization, risk evaluation, and integrated policy–economic assessment aimed at fostering the growth of clean energy markets.

Discussion and Conclusion

The findings of this scientometric study demonstrate a substantial and continuous growth in scholarly production related to renewable energy investment over the past two decades. The upward trajectory in publication output confirms that renewable energy investment has evolved from a specialized research niche into a central multidisciplinary field integrating management, economics, environmental science, and public policy. This

expansion reflects global recognition of renewable energy as a strategic instrument for addressing climate change, economic resilience, and long-term energy security challenges. The rapid growth of scientific publications corresponds with international policy shifts toward decarbonization and sustainable development frameworks that prioritize renewable energy deployment (1, 2).

The dominance of China and the United States in scientific production, as identified in the results, aligns with broader global energy transition dynamics. These countries have invested heavily in renewable infrastructure, technological innovation, and research capacity, thereby positioning themselves as knowledge leaders in the renewable energy domain. Previous studies have emphasized that large economies with strong institutional support and technological investment capabilities tend to lead renewable energy transitions and shape global energy governance structures (3). The central role of these countries in collaboration networks further indicates their influence in directing international research agendas and facilitating knowledge diffusion across regions.

The strong presence of European and emerging economies in the publication network highlights the increasingly global nature of renewable energy investment research. The participation of developing countries such as Iran, Pakistan, and Poland demonstrates the diffusion of renewable energy priorities beyond traditionally industrialized nations. This finding supports empirical evidence suggesting that renewable energy deployment is increasingly driven by diverse national motivations, including environmental protection, economic diversification, and energy independence (2). Renewable investment is therefore no longer confined to environmental policy alone but represents a broader developmental strategy adopted across economic contexts.

Keyword analysis revealed that concepts such as “investments,” “renewable energy,” “energy policy,” and “sustainable development” occupy central positions within the research network. The prominence of these themes reflects the interdependence between financial decision-making, technological adoption, and policy frameworks. Innovation-focused policy environments have been shown to accelerate renewable technology diffusion and market expansion, confirming the critical role of regulatory design in shaping investment flows (5). The strong association between investment and policy keywords observed in this study indicates that renewable energy development remains fundamentally policy-driven, requiring coordinated governance mechanisms.

The emergence of economic and financial terminology—such as costs, economic analysis, and risk assessment—within the keyword clusters further underscores the managerial and financial dimensions of renewable energy investment. Renewable energy projects are characterized by high initial capital requirements, long payback periods, and exposure to market uncertainty. Studies evaluating renewable investment risk confirm that financial evaluation methods and uncertainty management significantly influence investor participation and project feasibility (8). Similarly, recent research on energy transition risk dynamics highlights growing interconnectedness between renewable energy markets and fossil fuel systems, reinforcing the need for comprehensive risk management frameworks (9).

Another important finding concerns the strong representation of sustainability and environmental themes within the research network. Keywords related to climate change, carbon emissions, and greenhouse gases illustrate the environmental drivers motivating renewable energy investment. Environmental psychology and green finance research demonstrate that government expenditure, societal environmental awareness, and sustainable finance mechanisms collectively enhance renewable energy adoption (7). The integration of environmental considerations with economic investment decisions observed in this study confirms that renewable energy investment operates as both an environmental and economic transformation process.

The results also reveal the importance of technological diversification within renewable energy investment research. Keywords associated with solar energy, wind power, energy efficiency, and electricity generation indicate increasing attention to technological feasibility and operational optimization. Empirical assessments of solar photovoltaic deployment show that integrated techno-economic evaluation enables renewable systems to serve as viable pathways toward net-zero carbon transitions (13). Similarly, studies on demand-driven renewable systems, such as agricultural biogas investments, emphasize the growing role of localized technological solutions in expanding renewable energy markets (14). These findings support the argument that technological maturity has transformed renewable energy from an experimental innovation into a mainstream investment sector.

The prominence of journals such as *Energy Policy*, *Renewable Energy*, and *Applied Energy* indicates that renewable energy investment research is strongly anchored in policy analysis and applied energy economics. The concentration of publications within these outlets confirms the interdisciplinary nature of the field, combining policy evaluation, economic modeling, and technological assessment. Previous systematic reviews have similarly emphasized that renewable energy deployment depends on coordinated interactions among policy instruments, financial systems, and technological innovation ecosystems (2). The scientometric evidence presented here reinforces this integrated perspective.

Collaboration networks further reveal the centrality of international cooperation in advancing renewable energy research. The central positioning of major research economies within the collaboration map reflects patterns of knowledge exchange and collective problem-solving. Public–private partnerships and political cooperation have been identified as significant determinants of renewable energy investment expansion, particularly in rapidly developing economies (10). The observed collaboration structures suggest that renewable energy investment research increasingly relies on transnational scientific partnerships capable of addressing global sustainability challenges.

Another noteworthy implication of the findings relates to organizational and socio-technical transformation. Renewable energy systems require coordinated adaptation across technological, organizational, and human dimensions. Socio-technical systems theory emphasizes that successful technological transitions depend on aligning human competencies, institutional structures, and technological capabilities (4). The interdisciplinary clustering observed in this study reflects such alignment, where technological innovation interacts with managerial decision-making and institutional governance.

The growing emphasis on integrated resource planning and energy efficiency within the keyword network also reflects managerial innovation in energy systems. Strategic planning approaches enable organizations and governments to optimize energy consumption while improving sustainability performance (11). Evidence from sectoral energy management applications confirms that renewable energy investment contributes to operational efficiency improvements and long-term cost reduction (12). These findings highlight the managerial relevance of renewable energy beyond national policy debates, extending into organizational strategy and operational management.

Financial sustainability remains another central theme emerging from the discussion of results. Renewable energy investment increasingly relies on innovative financing mechanisms, including blended finance, green bonds, and sustainable investment funds. Early analyses of renewable energy financing strategies emphasized the importance of diversified funding structures to support industry growth and reduce investment barriers (6). Contemporary research expands this perspective by demonstrating how sustainable finance frameworks integrate

environmental goals with economic development outcomes across sectors (15). The scientometric patterns observed in this study confirm that financial innovation constitutes a foundational pillar of renewable energy expansion.

Moreover, the results highlight the growing linkage between renewable energy investment and human capital development. Empirical research shows that investments in renewable infrastructure combined with human capital enhancement significantly improve renewable energy consumption and environmental sustainability outcomes (17). This relationship suggests that renewable energy transitions require not only technological investment but also institutional learning, workforce development, and knowledge transfer mechanisms.

Methodologically, the increasing adoption of systematic review and scientometric approaches reflects the maturation of renewable energy research as a scientific field. The use of structured analytical frameworks enhances transparency and enables comprehensive synthesis of large bodies of literature, consistent with updated reporting standards for evidence synthesis (16). The present study contributes to this methodological advancement by mapping intellectual structures and identifying dominant research trajectories within renewable energy investment scholarship.

Overall, the discussion indicates that renewable energy investment research has evolved into an integrated knowledge ecosystem connecting sustainability objectives, financial innovation, technological advancement, and policy governance. The alignment between the empirical findings and prior studies confirms that renewable energy investment is fundamentally multidimensional, requiring coordinated action across economic, environmental, and institutional domains.

Despite providing comprehensive insights, this study has several limitations. First, the analysis relied exclusively on publications indexed in the Scopus database, which may exclude relevant studies published in regional journals or alternative indexing platforms. Second, scientometric methods primarily capture quantitative publication patterns and citation relationships, potentially overlooking qualitative nuances such as contextual policy differences or institutional variations. Third, keyword-based searches may introduce bias due to terminology differences across disciplines and countries. Finally, citation counts may favor older publications, potentially underrepresenting emerging research topics that have not yet accumulated significant citations.

Future research should expand scientometric analyses by integrating multiple databases such as Web of Science and Google Scholar to enhance coverage and comparative validity. Longitudinal analyses examining thematic evolution over shorter time intervals could provide deeper insights into emerging research fronts. Researchers may also combine bibliometric methods with qualitative content analysis to better understand theoretical developments and policy implications. Comparative regional studies investigating differences between developed and developing economies would further clarify how institutional contexts shape renewable energy investment patterns. Additionally, future studies could explore interdisciplinary intersections between renewable energy investment, artificial intelligence, digital finance, and smart energy systems to capture the next phase of energy transition research.

Practitioners and policymakers should prioritize stable regulatory environments that reduce investment uncertainty and encourage long-term renewable energy financing. Governments can strengthen international collaboration mechanisms to facilitate knowledge transfer and technological diffusion. Energy firms and investors should adopt integrated risk assessment frameworks combining economic, environmental, and technological evaluations when planning renewable projects. Organizations are encouraged to invest in workforce training and

institutional learning programs to support renewable energy adoption. Finally, financial institutions should expand green financing instruments and innovative funding mechanisms to accelerate the transition toward sustainable and resilient energy systems.

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Authors' Contributions

All authors equally contributed to this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

All ethical principles were adheried in conducting and writing this article.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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