International Journal of Automotive & Transportation Engineering
ISSN: 3083-9726

# Renewable energy integration and management: Bibliometric analysis and application of advanced technologies

**Muhammad Nizar[1], Syaifuddin Yana[2], Bahagia[1], Ahmad Fitri Yusop[3], Erdiwansyah[4,5*]**

[1]Department of Environment Engineering, Universitas Serambi Mekkah, Banda Aceh, 23245, Indonesia
[2]Department of Economic Management, Faculty of Engineering, Universitas Serambi Mekkah, Banda Aceh, 23245, Indonesia
[3]Faculty of Mechanical and Automotive Engineering Technology, Universiti Malaysia Pahang Al-Sultan Abdullah, Malaysia
[4]Department of Natural Resources and Environmental Management, Universitas Serambi Mekkah, Banda Aceh, 23245, Indonesia
[5]Centre for Automotive Engineering, Universiti Malaysia Pahang Al Sultan Abdullah, Malaysia

Corresponding authors: erdiwansyah5@gmail.com

## Abstract
This study critically examines the integration and management of renewable energy through bibliometric analysis and the application of advanced technologies, aiming to uncover major research trends, technological innovations, and ongoing challenges in the field. By analysing scientific publications from 2021 to 2023 using the Scopus and Web of Science databases, the research focuses on critical topics such as renewable energy management, advanced technologies, and emerging global collaborations. The findings reveal a substantial rise in research output, particularly in solar and wind energy, alongside a growing emphasis on international cooperation. Notably, advanced technologies like the Internet of Things (IoT), artificial intelligence (AI), and blockchain are identified as pivotal in enhancing the operational efficiency and control of renewable energy systems. However, critical challenges persist, such as the lack of robust policy frameworks, insufficient infrastructure, and the complexity of system integration. This research underscores the necessity of adopting a multidisciplinary approach and comprehensive policy support to facilitate long-term, sustainable energy solutions. These insights offer valuable guidance for researchers, industry professionals, and policymakers in shaping future strategies to optimise the use of renewable energy.

**Article Info**
Received: 13 January 2025
Revised: 05 February 2025
Accepted: 10 February 2025
Available online: 25 May 2025

**Keywords**
Renewable energy
Bibliometric analysis
Artificial intelligence
Energy storage
Thermal management

## 1. Introduction
In recent decades, renewable energy has become a significant concern worldwide as a solution to reduce dependence on fossil fuels and mitigate the impacts of climate change. Renewable energies such as solar power, wind and bioenergy offer sustainable and environmentally friendly alternatives [1–6]. As awareness of the importance of sustainability increases, research and innovation in renewable energy

technology continues to grow [7–10]. This visualisation overview of the bibliometric analysis provides insight into how various concepts and technologies relate to each other in the context of renewable energy. The integration of advanced technologies such as artificial intelligence, hybrid energy storage and thermal management plays a crucial role in increasing the efficiency and effectiveness of renewable energy systems [11–15] Artificial intelligence, for example, can be used to optimise energy management, predict energy demand, and increase the resilience of energy systems. Energy storage technologies, including batteries and fuel cells, enable more effective and stable energy storage, thereby overcoming the intermittency problems often associated with renewable energy sources such as wind and solar [16–19].

Renewable energy has experienced significant growth in recent years, driven by increasing awareness of climate change and the need to reduce dependence on fossil fuels [20–22]. Technologies such as solar, wind and hydroelectric power have experienced rapid developments in efficiency and production costs [23–26]. For example, falling solar panels and wind turbine costs have made renewable energy more affordable and competitive than conventional energy sources [27–30]. According to a report from the International Renewable Energy Agency (IRENA), global renewable energy capacity has more than doubled in the last decade, with solar and wind power as the main contributors [31–34]. This reflects substantial investment and policies supporting the green energy transition in many countries.

Additionally, innovations in energy storage and smart grid integration have played an essential role in accelerating the adoption of renewable energy [35–38]. More advanced battery technology enables more efficient energy storage, which is essential for overcoming the intermittency problems often associated with renewable energy sources [39–43]. Additionally, advances in power grid management systems have increased the ability to integrate multiple renewable energy sources into existing power grids, improving the stability and reliability of energy supply [36,44–46]. Proactive government policies, financial incentives and international commitments to reduce carbon emissions have also driven the growth of this sector [47–50]. Although challenges remain, especially regarding infrastructure and regulatory adjustments, the outlook for renewable energy remains bright, with more countries committing to achieving clean energy targets in the coming decades.

Thermal management is also an essential aspect of renewable energy systems. An efficient thermal management system can improve the performance and lifespan of energy storage devices and reduce operational costs [51–55]. In the context of hybrid electric vehicles, good thermal management not only improves fuel efficiency but also extends battery life and reduces the risk of system failure [56–59]. Visualisation of the bibliometric analysis shows that research in this field continues to grow, with many studies focusing on innovation and improvement of thermal management technologies [60–64]. This research also shows that the adoption of renewable energy technology is not only significant from a technical perspective but also from an economic and social aspect. For example, climate change mitigation and circular economy sustainability are important focuses in recent research [65–67]. The use of renewable energy in various sectors, including industry and transportation, has the potential to reduce greenhouse gas emissions and create a more sustainable economy [47,68–71]. This visualization shows the close relationship between these concepts, underscoring the importance of a multidisciplinary approach in renewable energy research.

In the context of renewable energy integration and management, a growing body of literature reflects the importance of effectively managing energy resources to meet the ever-increasing global energy demand. For example, bibliometric analysis for 2007-2022 shows a significant increase in publications related to energy storage and intelligent control technologies in distributed grids, with an average annual growth rate of 15% [72–75]. In addition, technological advances such as artificial intelligence (AI) and machine learning-based optimisation algorithms have improved operational efficiency and energy demand prediction in hybrid systems that combine multiple renewable energy sources, such as photovoltaics and wind turbines [76–78]. With the depletion of fossil fuels and the increasing need to reduce carbon emissions, recent studies indicate that adopting these technologies could reduce operational costs by up to 25% and carbon emissions by 30% in the next 10 years. A review of the existing literature suggests that although many studies have found these technologies' potential, most still focus on simulation models or specific case studies. To get a complete picture, we need a review that includes global trends, technical challenges, and advanced technology applications. This makes this review significant, as it fills the gap in the literature by providing a broader map of renewable energy management using advanced technologies.

This study aims to identify and analyse the relationships between various concepts in the renewable energy field, including thermal management, energy storage, and advanced technologies such as artificial intelligence and hybrid electric vehicles. This study maps critical trends and relationships in scientific literature through bibliometric analysis while providing insights into how advanced technologies can support integrating and adopting renewable energy more effectively. More specifically, this study also focuses on how these technologies can improve the efficiency of renewable energy systems, optimise energy management, and minimise environmental impacts, with the hope of providing recommendations that policymakers and industry can use in driving the transition to a more sustainable energy system.
The novelty of this research lies in its holistic approach that combines various aspects of technology and sustainability and its contribution to help policymakers, researchers, and practitioners develop more effective strategies to achieve energy sustainability. According to recent research, there has been a significant advancement in the management and integration of renewable energy due to the growing urgency to address climate change and the global shift toward sustainable energy sources. Recent bibliometric analysis shows a considerable increase in studies focusing on developing and applying advanced technologies such as smart grids, energy storage systems, and artificial intelligence. Recent trends indicate the optimization of energy distribution networks, integrating distributed energy sources, and applying predictive technologies for maintenance aimed at reducing downtime and operational costs. In addition, recent research trends also highlight the importance of blockchain technology in improving security and transparency in renewable energy management systems, as well as the role of the Internet of Things (IoT) in monitoring and managing energy usage in real-time. The concept of 'energy as a service' is also gaining attention, where energy consumers can participate in energy markets through more decentralized schemes. Cross-sector collaboration between academia, industry, and policymakers is increasingly crucial to addressing existing challenges, including regulation and financing, to accelerate the transition to a more sustainable, low-carbon future.

## 2. Methodology

In this study, a search of the Scopus and Web of Science databases was conducted using a set of keywords designed to cover critical topics related to the integration of renewable energy and advanced technologies. Keywords such as renewable energy, energy management, and advanced technology were the focus to ensure a broad coverage of publications relevant to current trends in renewable energy. In Scopus, the search used strings like "renewable energy AND energy management AND technology along with changes to include different technical terms, such as smart grid, energy storage, and hydrogen technologies, to find studies about the newest developments in energy management and storage technologies. Meanwhile, in Web of Science, the search was structured using the strings renewable energy AND integration AND advanced technology, ensuring that publications focusing on integrating renewable energy with the global energy grid and advanced technologies were identified. The combination of these carefully designed search strings allowed for a comprehensive analysis of publications from 2021 to 2023 related to renewable energy, grid integration, and advanced technology applications.

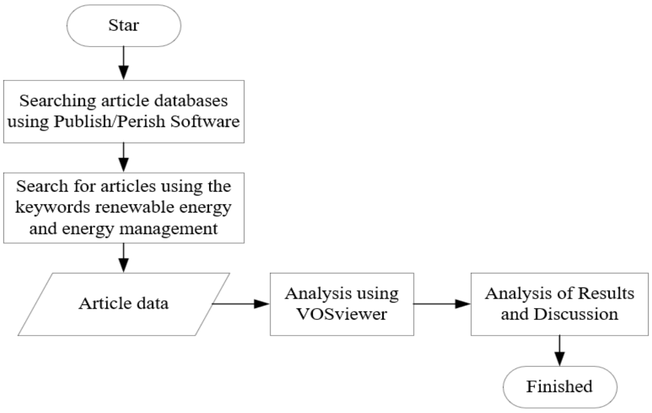


Fig. 1. Flowchart of data search and analysis using VOSviewer

**Fig. 1** shows the literature research workflow, which starts by searching for scientific articles using Publish/Perish software with the keywords renewable energy and energy management. The articles found are then collected as data to be analyzed using VOSviewer software, which functions for bibliometric analysis. The results are then interpreted and discussed in the analysis and discussion stage until the research is complete.

This research uses bibliometric analysis methods to explore research trends and advanced technology applications in renewable energy integration. Articles relevant to the research topic were identified and downloaded for further analysis. The collected data was analysed using VOSviewer software. VOSviewer is a tool used to create network maps and visualise bibliometric data. The analysis process involves the following steps:

a. Raw data from the database was extracted and reformatted to be compatible with VOSviewer. This step includes removing duplicates and filtering out irrelevant articles.
b. Using VOSviewer, a keyword network is built based on the frequency of occurrence and co-occurrence of keywords in selected articles. Keywords that appear together in the same article are connected by lines, with the line thickness indicating the strength of the relationship.
c. VOSviewer groups keywords into different clusters based on their proximity and relationship. Each cluster is identified with a different colour, making the results easier to interpret.
d. The resulting network maps were analysed to identify key themes, critical relationships between concepts, and current research trends in renewable energy and related technologies.

To ensure the validity of the results, a cross-check was carried out on some of the most frequently occurring articles, and additional analysis was carried out to verify the critical relationships identified from the visualisation. In addition, consultations with experts in renewable energy and advanced technology were conducted to gain additional insight and confirm the analysis results. The results of the bibliometric analysis are presented in the form of visual network maps, tables, and graphs that depict the distribution of keywords and the relationships between concepts and main research clusters. A detailed explanation of key findings, research trends, and potential applications of advanced technologies in renewable energy integration is included in the research report.

The period from 2021 to 2023 is highly relevant for understanding renewable energy trends due to significant developments influenced by various global and technological factors. Bibliometric analysis of scientific publications from Scopus and Web of Science databases with keywords such as renewable energy, energy management, and advanced technologies shows several critical reasons for the importance of this period. First, increasing global awareness of climate change is driving the adoption of clean energy as countries strive to meet the accelerated carbon emission reduction targets set by the Paris Agreement. Second, technological innovations, especially in energy storage, efficiency, and the integration of intelligent technologies such as AI and IoT, are advancing rapidly, enabling broader and more effective implementation of renewable energy. Third, following the COVID-19 pandemic, many countries are directing their policies and economic stimulus to accelerate the clean energy transition, creating jobs and driving sustainable growth. In addition, increased funding for research and development and policy support from various countries are also important factors that accelerate the growth of the renewable energy sector during this period. Analysis of scientific publications during this period helps us understand the direction of technological developments, challenges, and opportunities in the transition to clean energy.

This study used explicit inclusion and exclusion criteria to ensure transparency and replication. Inclusion criteria included articles published between 2021-2023 in English, peer-reviewed, and focused on renewable energy, energy management, and advanced technologies. Articles also examined the latest technological innovations, such as energy storage, smart grids, and hydrogen technologies. Conversely, exclusion criteria included articles that only provided an overview without empirical analysis, theoretical articles without practical applications, publications that were not available in full text, and works that were irrelevant to the main keywords or published in languages other than English. With these criteria, the study focused on the most relevant and quality articles while ensuring that the selection process could be repeated transparently.

## 3. Results

Before 2021, several significant developments laid the foundation for today's renewable energy research and advanced technologies. Advances in energy storage technologies, particularly lithium-ion batteries, have enabled large-scale energy storage to address the challenges of renewable energy intermittency. In addition, the development of intelligent grids has enabled real-time monitoring and more efficient load management, supported by AI and IoT technologies, which have improved grid stability. Green hydrogen technology was also developed before 2021 as a potential solution for decarbonising the industrial and transportation sectors. On the policy side, the 2015 Paris Agreement has played a crucial role in driving massive investment in clean energy, accelerating innovation and research in renewable energy today. All these developments have laid a strong foundation for continued innovation in renewable energy integration and more efficient energy management.

Research related to publication distribution by year and country applied in this manuscript aims to explain how research trends related to renewable energy and energy management are developing in various countries from 2021-2023. In addition, the main keywords and relationships between themes in renewable energy can direct readers to the findings from the keyword co-occurrence analysis, which shows dominant topics such as energy storage technology, green hydrogen, and smart grids. Furthermore, the collaboration of authors and institutions on renewable energy research can explain the collaboration network formed between researchers and global institutions in advancing renewable energy technologies. Finally, advanced technology applications in energy management: innovations and challenges can focus on how advanced technologies such as AI, IoT, and energy storage are used to overcome the challenges of integrating renewable energy into the electricity grid. With a more detailed sub-heading structure, readers can more easily navigate and understand each section of the findings relevant to renewable energy integration and advanced technology applications.

**Table 1** comprises various technological applications in renewable energy and electric vehicles. The Application category stands out with a total link strength of 8 and 6 occurrences, indicating the importance of technology application in renewable energy research in 2022. This category shows that the study primarily focuses on the practical application of the technology being developed, covering various related fields with energy and the environment. Furthermore, the categories Fuel cell and Thermal management also play an essential role in this cluster. The Fuel cell category has a total link strength of 14 and 5 occurrences, indicating that research related to fuel cells is receiving significant attention. This research is essential for developing more efficient and environmentally friendly energy technology. Likewise, Thermal management shows a total link strength of 18 and 9 occurrences, emphasising the importance of thermal management in developing renewable energy technologies. Effective thermal management is critical to improving the efficiency and sustainability of energy systems.

Other categories, such as Hybrid electric vehicles, deep reinforcement learning, and energy conversion, show significant total link strengths and occurrences. This indicates that research does not just focus on one aspect of technology but covers various approaches and solutions to overcome renewable energy challenges. The hybrid electric vehicle category, with a total link strength of 7 and 6 occurrences, shows that hybrid electric vehicles are a very active research area. Likewise, the categories deep reinforcement learning and dynamic programming demonstrate the application of advanced methods in optimising and managing energy systems, showing how the latest technologies are applied to solve complex problems in the field of renewable energy.

**Table 1**. Cluster 1 is the relationship between technology applications and renewable energy

| Id | Categories | Weight Links | Total link strength | Occurrences | Year |
|---|---|---|---|---|---|
| 2 | Application | 8 | 8 | 6 | 2022.1667 |
| 11 | Comparative study | 3 | 3 | 3 | 2022 |
| 17 | Deep reinforcement learning | 5 | 6 | 5 | 2022.2 |
| 18 | Dynamic programming | 3 | 4 | 3 | 2022.3333 |
| 21 | Energy conversion | 5 | 8 | 4 | 2022 |
| 26 | Fuel cell | 12 | 14 | 5 | 2022 |

| Id | Categories | Weight Links | Total link strength | Occurrences | Year |
|---|---|---|---|---|---|
| 29 | Hybrid electric vehicle | 5 | 7 | 6 | 2022.1667 |
| 40 | PCM | 3 | 5 | 3 | 2022 |
| 41 | Plug | 2 | 3 | 4 | 2022 |
| 44 | Progress | 5 | 8 | 5 | 2022 |
| 48 | Rule | 6 | 8 | 7 | 2022 |
| 59 | Term | 7 | 7 | 4 | 2022 |
| 60 | Thermal management | 11 | 18 | 9 | 2022 |

The bibliometric visualisation shows some of the main clusters in renewable energy research. These include energy storage, thermal management, artificial intelligence, hybrid electric vehicles, and sustainability. Different colours identify these clusters, each indicating close relationships between the concepts. The results of the analysis show that artificial intelligence and energy storage technology are closely related to research areas. Keywords such as deep reinforcement learning and hybrid energy storage frequently appear together, indicating that this research often explores how artificial intelligence can improve the efficiency and effectiveness of energy storage systems.

The visualisation also shows that thermal management and hybrid electric vehicle technology are significant focus areas. Keywords such as thermal management and hybrid electric vehicles appear in the same cluster, indicating that effective thermal management is the key to improving hybrid electric vehicles' performance and service life. Another prominent cluster covers the concepts of sustainability and climate change mitigation. Keywords such as sustainability, climate change, and circular bioeconomy indicate that renewable energy research should not only focus on technical aspects but also environmental and social impacts. Network visualisation shows the complex interconnections between various concepts in renewable energy research. The relationship between energy conversion, fuel cells, and renewable energy sources shows that technological innovation in energy conversion and renewable energy sources is the focus of this research.

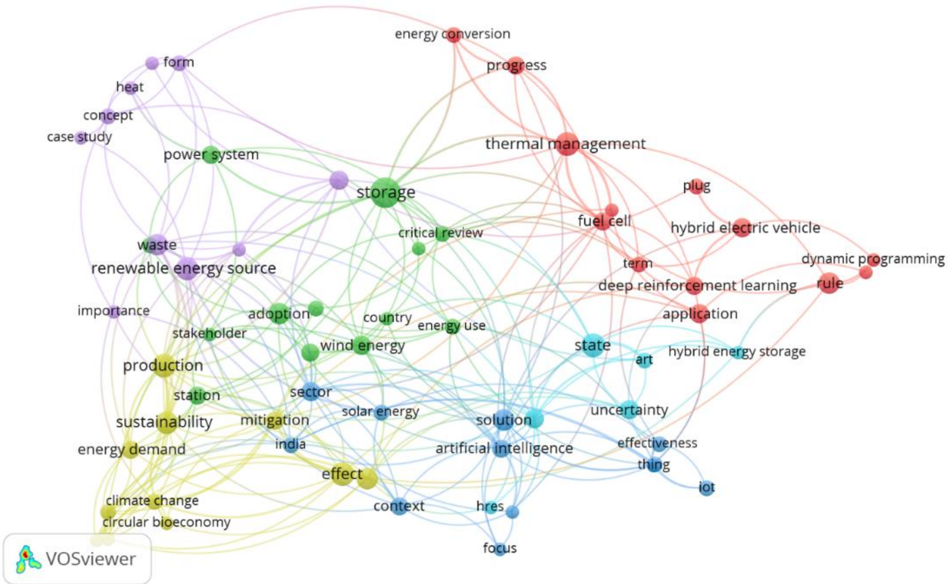


**Fig. 2**. Renewable energy bibliometric network map

**Fig. 2** shows a network map of keywords in research on renewable energy from 2022 to 2024. The keywords relate to various aspects of renewable energy integration and management. Some main keywords that stand out are storage, wind energy, sustainability, artificial intelligence, and thermal management. These keywords indicate that current research focuses not only on renewable energy production but also on storage, thermal management, and the application of advanced technologies, such as artificial intelligence, to increase the efficiency and effectiveness of renewable energy.

Keyword developments from 2022 to 2024 indicate new trends and focus in renewable energy research. For example, keywords such as artificial intelligence and deep reinforcement learning indicate the increasing use of advanced technologies in renewable energy management and integration. In addition, there is also increasing interest in sustainability and renewable energy sources, which reflects growing concern for environmental sustainability and reducing carbon emissions. The relationship between these keywords indicates multidisciplinary integration, combining technical, management, and ecological aspects in renewable energy research. The time trends represented by colours in this network map provide additional insight into research progress. Newer keywords, such as dynamic programming and hybrid energy storage, appear in yellow, indicating that these topics are the focus of recent research. In contrast, older keywords such as production and waste appear in blue, indicating that these topics have been fundamental in renewable energy research but may have changed how they are addressed. Overall, this figure shows that renewable energy research continues to develop rapidly, adopting new technologies and focusing on sustainability to achieve clean and efficient energy goals.

In this network map, several technologies have strong relationships, shown in **Fig. 2**. For example, the words related to thermal management, fuel cells, and hybrid electric vehicles (in red) show a strong relationship between these technologies. Technologies such as fuel cells and hybrid electric vehicles are more widely used in thermal management, which is very important for the efficiency and stability of electric vehicles. This shows that these technologies are more commonly applied in the automotive or transportation sectors that require effective thermal management. On the other hand, storage technology appears in the middle of the diagram with extensive links to other terms such as renewable energy source and power system. This indicates that energy storage technology plays a central role and is flexible, which can be used in various sectors or areas that require stability and sustainability of renewable energy sources. The green word cluster includes terms such as sector, station, renewable energy source, and sustainability. The relationship between these terms indicates that renewable energy sources are becoming increasingly crucial in specific sectors, especially those focused on sustainability. These sectors are likely to include the energy industry and public infrastructure sectors, with a high focus on reducing environmental impacts and implementing cleaner energy. In addition, the terms mitigation and production connected to renewable energy sources indicate that the production sector, especially those related to processing or heavy industry, may be more inclined to use renewable energy sources as an effort to mitigate climate change.

In the blue group of words, the terms country, India, solar energy, and energy use are visible. This shows that solar energy is more dominant in specific regions or countries, such as India. This may be due to geographical factors that allow for the availability of sunlight throughout the year, as well as energy policies that support the implementation of renewable energy in the region. Terms such as climate change and energy demand connected to the region also show that in regions with high energy needs and pressures from climate change, the adoption of renewable energy technologies is more significant. Countries or regions with high environmental awareness may prefer sustainable energy technologies. In the red cluster, terms such as dynamic programming, deep reinforcement learning, and hybrid energy storage indicate that AI-based technologies and dynamic programming are more often used in the context of hybrid energy or electric vehicles. These technologies may be more relevant in areas with advanced energy infrastructure, where optimising complex energy systems is essential. Meanwhile, the terms artificial intelligence and IoT (internet of things) at the bottom indicate the use of digital technologies to manage and optimize energy use. This is more relevant in sectors requiring real-time energy monitoring and control, such as the manufacturing industry or public infrastructure.

**Table 2**. Cluster II Renewable Energy Integration

| Id | Categories | Links | Total link strength | Occurrences | Score Average. Publications/year |
|---|---|---|---|---|---|
| 1 | Adoption | 11 | 12 | 7 | 2022.429 |
| 5 | Article | 5 | 5 | 5 | 2022.6 |
| 14 | Country | 7 | 7 | 3 | 2022 |
| 16 | Critical Review | 9 | 9 | 4 | 2022 |
| 23 | Energy use | 9 | 9 | 4 | 2022.25 |
| 32 | Hydrogen | 6 | 7 | 3 | 2022.333 |

| Id | Categories | Links | Total link strength | Occurrences | Score Average. Publications/year |
|---|---|---|---|---|---|
| 42 | Power System | 6 | 8 | 5 | 2022.2 |
| 47 | Risk | 5 | 5 | 4 | 2022 |
| 53 | Stakeholder | 9 | 10 | 3 | 2022.333 |
| 55 | Station | 8 | 8 | 5 | 2022.4 |
| 56 | Storage | 14 | 20 | 15 | 2022.133 |
| 63 | Use | 4 | 5 | 4 | 2022 |
| 65 | Wind energy | 8 | 8 | 6 | 2022 |

**Table 2** displays the results of the bibliometric analysis carried out using VOSViewer, focusing on the categories in Cluster II related to renewable energy and its integration. The categories listed cover various vital aspects such as technology adoption, scientific articles, countries, critical reviews, energy use, hydrogen, power systems, risks, stakeholders, stations, storage, and wind energy. Each category is measured based on several metrics, such as the number of links, total link strength, occurrences and average score of publications per year. These categories reflect the latest research trends and focus on renewable energy. For example, the categories adoption and stakeholders indicate the importance of understanding how new technologies are received by society and the role of various stakeholders in the process. The hydrogen and storage categories highlight attention to energy storage technologies and hydrogen solutions as critical components in future energy systems. Likewise, power systems and wind energy focus on developing and integrating power systems that use renewable energy sources. **Table 2** shows that these topics are highly relevant and are current research areas, with a consistent average publication year around 2022. This indicates a significant push in the scientific community to address challenges and explore opportunities in renewable energy integration. This analysis provides a comprehensive view of how various aspects are interrelated in efforts to achieve energy sustainability and reduce dependence on fossil energy sources.

**Table 3**. Cluster III advanced technologies in sustainable energy

| Id | Categories | Links | Total link strength | Occurrences | Score Average Publications/ year |
|---|---|---|---|---|---|
| 6 | Artificial intelligence | 15 | 17 | 5 | 2022.6 |
| 13 | Context | 10 | 10 | 5 | 2022.4 |
| 20 | Effectiveness | 6 | 6 | 4 | 2022 |
| 24 | Focus | 4 | 4 | 3 | 2022.333 |
| 34 | India | 11 | 11 | 4 | 2022.25 |
| 35 | Internet | 8 | 10 | 4 | 2022.25 |
| 36 | IoT | 3 | 3 | 4 | 2022.25 |
| 50 | Sector | 16 | 18 | 6 | 2022.5 |
| 51 | Solar energy | 6 | 7 | 4 | 2022 |
| 52 | Solution | 15 | 15 | 7 | 2022.143 |
| 58 | Sustainable energy | 7 | 8 | 3 | 2022.333 |
| 61 | Thing | 8 | 10 | 3 | 2022.333 |

**Table 3** displays the results of bibliometric analysis from Cluster III relating to advanced technology and sustainable energy. The categories listed include artificial intelligence, context, effectiveness, focus, India, internet, Internet of Things (IoT), sector and solar energy, solutions (Solution), sustainable energy (Sustainable Energy), and objects (Thing). Each category is assessed based on metrics such as number of links, total link strength, occurrences and average score of publications per year. This analysis shows significant attention to advanced technologies such as artificial intelligence and IoT in the context of sustainable energy. For example, the artificial intelligence category has a high total link strength and frequency of occurrence, indicating that the use of AI in sustainable energy is a topic of great interest and growth. Likewise, the IoT and internet categories highlight the importance of network technologies

in optimising the use and management of renewable energy resources. The solution category has many links and link strengths and focuses on developing practical solutions to renewable energy challenges. The sector and solar energy categories indicate that the research focuses on technology, practical applications in various industrial sectors, and specific energy sources such as solar energy. It demonstrates a holistic approach to energy sustainability, including advanced technologies and real-world implementation. In addition, the sustainable energy category underlines the commitment to achieving long-term sustainability through technological innovation. Overall, this table indicates that integrating advanced technologies in the energy sector is a very active and relevant research area. This research covers various aspects, from technology implementation and solution effectiveness to geographic focus, such as India. It provides a comprehensive view of how advanced technologies can achieve sustainable energy goals and overcome the challenges inherent in the global energy transition.
**Fig. 3** results from a bibliometric analysis showing research trends, main keywords in renewable energy integration and management, and advanced technology applications. Energy storage is one of the main focuses of this analysis. Energy storage is essential in renewable energy integration because it helps overcome the intermittent nature of energy sources such as solar and wind. Energy storage technology allows electricity to be stored when excess production is used, when demand is high, or when production decreases.

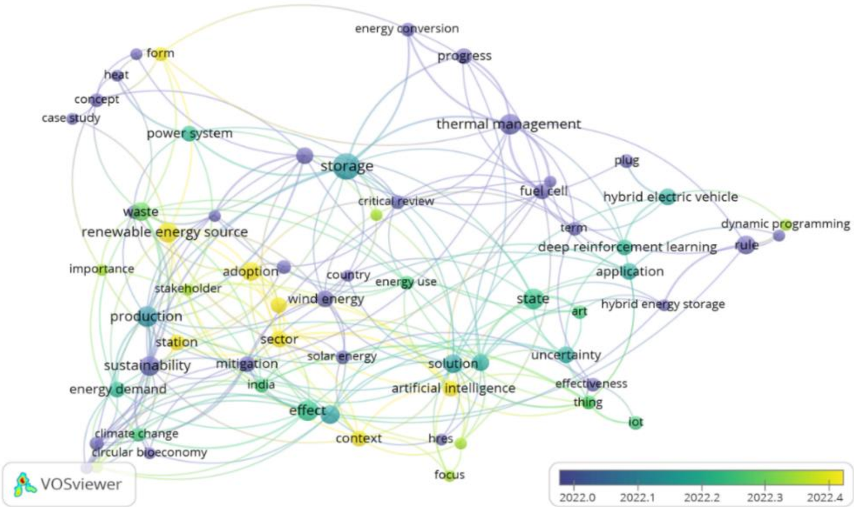


**Fig. 3**. Visualization of relationships between various keywords

Additionally, keywords such as thermal management and fuel cells indicate significant interest in thermal management and fuel cell technologies as solutions to increase the efficiency and reliability of renewable energy systems. Thermal management is critical in maintaining the optimal performance of energy storage devices and energy conversion systems. Fuel cells, on the other hand, offer great potential to produce electricity with high efficiency and very low emissions, making them an essential component in future energy systems. Other outstanding topics are renewable energy sources, sustainability, and production. This shows that research also focuses on renewable energy sources, sustainability and energy production. Sustainability is critical in developing renewable energy technologies, which aim to reduce environmental impacts and ensure energy availability for future generations. Research in this area also covers adopting renewable energy technologies in various sectors and countries and mitigating the challenges faced in large-scale integration. Finally, this analysis shows a strong interest in using advanced technologies such as artificial intelligence and deep reinforcement learning in renewable energy management. These technologies optimise energy system operations, predict energy demand and production, and improve efficiency. Thus, this bibliometric analysis provides a comprehensive picture of the research and technological advances that play a role in integrating and managing renewable energy and indicates the expected future directions in this field.
Compared with previous studies, this study's topic network shows an increasing link between smart technology and energy management, which is not as straightforward as in previous studies [79]. The report noted the importance of renewable energy integration through storage technology and grid

management but did not explicitly highlight the role of artificial intelligence (AI). Meanwhile, Rana [80] stated that research trends focus more on developing physical technologies, such as solar and wind, without much attention to smart technologies, such as AI and IoT. However, AI and IoT emerge as integral to energy management solutions in this latest topic map. This indicates a shift from technical optimisation to data-driven energy grid prediction and optimisation technologies. This shows how recent developments in machine learning and optimisation technologies have influenced the direction of renewable energy research.

**Table 4** displays the results of bibliometric analysis from Cluster IV relating to sustainability and resilience in the energy system. The categories listed include circular bioeconomy, climate change, Covid effects, energy demand, mitigation, pandemic, production, pyrolysis (Pyrolysis), section (Section), and sustainability (Sustainability). Each category is assessed based on metrics such as number of links, total link strength, occurrences and average score of publications per year. This analysis shows that significant attention is paid to issues affecting the sustainability and resilience of energy systems in the context of global challenges. The Climate Change and COVID categories highlight the importance of understanding the impact of climate change and pandemics on energy systems. These categories have many links and strengths, indicating that research in this area is a highly relevant and critical topic. The Pandemic category also shows how global emergencies affect energy demand and production.

The energy demand and mitigation categories show attention to how energy demand is managed and mitigation efforts undertaken to reduce negative environmental impacts. With significant link strength and events, the sustainability category is committed to achieving a sustainable energy system. This research on mitigation and sustainability shows that efforts to reduce climate change's impacts and increase energy systems' resilience are critical. Overall, this table indicates that research in Cluster IV focuses on challenges and solutions to ensure sustainable and resilient energy systems. From bio-circular economy uses to pyrolysis and energy production, these categories reflect a holistic approach to addressing complex environmental and global issues. This analysis provides a comprehensive view of how research and innovation can help develop energy systems more resilient to future changes and challenges.

**Table 4**. Cluster IV sustainability and resilience in energy systems

| Id | Categories | Links | Total link strength | Occurrences | Score Average Publications/ year |
|---|---|---|---|---|---|
| 8 | Circular bioeconomy | 4 | 5 | 3 | 2022 |
| 10 | Climate Change | 9 | 13 | 4 | 2022.25 |
| 15 | Covid | 11 | 13 | 4 | 2022 |
| 19 | Effect | 14 | 15 | 9 | 2022.222 |
| 22 | Energy demand | 11 | 12 | 5 | 2022.2 |
| 37 | Mitigation | 12 | 14 | 5 | 2022 |
| 39 | Pandemic | 8 | 10 | 3 | 2022 |
| 43 | Production | 14 | 20 | 9 | 2022.111 |
| 45 | Pyrolysis | 7 | 8 | 3 | 2022.333 |
| 49 | Section | 12 | 13 | 7 | 2022.143 |
| 57 | Sustainability | 12 | 17 | 8 | 2022 |

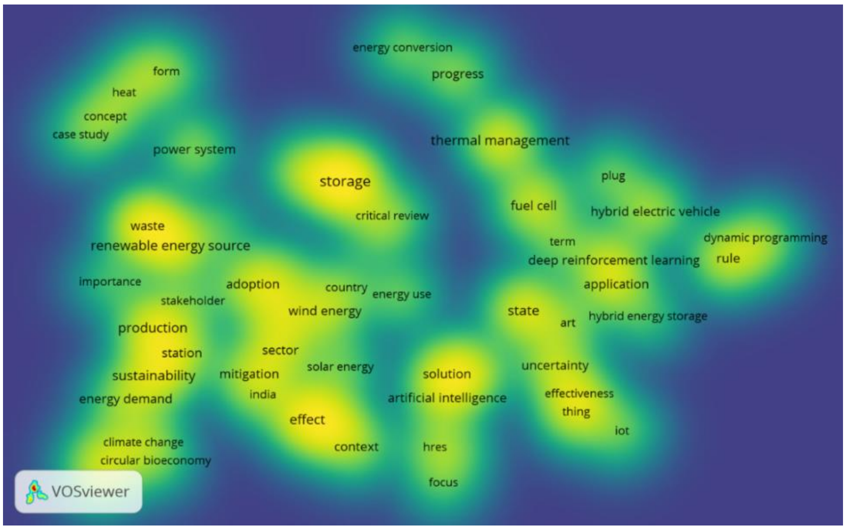


**Fig. 4**. Renewable energy topic density map

**Fig. 4** shows a topic density map generated using VOSviewer software, which identifies key research topics in renewable energy based on the frequency of occurrence and relationships between keywords in the literature. The map's colour indicates the density of the frequently occurring topic; the lighter the colour, the higher the frequency of the related keyword in the publications. The most frequently occurring issues in the renewable energy literature are storage, wind energy, artificial intelligence, and renewable energy sources, all shown in very bright yellow on the map. This indicates a strong focus of the research community on these areas, especially on energy storage technologies, which are critical to integrating renewable energy into the electricity grid. In addition, the map also shows several clusters representing related subtopics. For example, topics such as thermal management and fuel cells relate to thermal energy management technologies and fuel cells, which are in one cluster.

On the other hand, technologies such as deep reinforcement learning and artificial intelligence appear in different clusters, indicating intelligent technologies' critical role in optimising and managing renewable energy systems. This is also evident from keywords such as IoT and dynamic programming, which indicate the application of modern technologies in renewable energy management. The topics of uncertainty and effectiveness show challenges regarding the reliability of renewable energy systems, which are also a significant concern in current research. Overall, this map provides essential insights into the current research focus and technologies applied in developing renewable energy systems and the challenges that still need to be addressed.

Compared to previous studies, this topic map shows an increasing focus on intelligent technologies such as artificial intelligence (AI) and the Internet of Things (IoT), which were not widely discussed in previous studies, such as the study by [81–83] only covered the application of AI in renewable energy system optimisation to a limited extent. In contrast, in this topic map, AI emerges as one of the critical topics that continue to grow along with the increasing adoption of this technology in various renewable energy applications, including energy management, load prediction, and grid optimisation. Similarly, Rana [80,84,85] reported that research on energy storage and renewable energy sources (such as wind and solar) dominated the literature. Still, in this latest analysis, there is a more explicit shift towards more efficient storage technologies, the application of machine learning algorithms, and the management of the complexity of hybrid systems. Furthermore, topics such as deep reinforcement learning and blockchain, now essential parts of renewable energy system management, were not widely explored in previous literature, indicating significant technological developments in recent years [79,86,87]. Therefore, this topic map provides a more modern perspective on research trends and challenges in renewable energy integration.

**Table 5** displays the results of the bibliometric analysis of Cluster V relating to innovative approaches in renewable energy and the circular economy. The categories listed include architecture, case study, circular economy, concept, form, heat, importance, order, renewable energy sources (Renewable Energy Source), and waste (Waste). Each category is assessed based on metrics such as number of links, total link strength, occurrences and average score of publications per year. This analysis shows that

significant attention is peconomicapplying circular economy principles in the context of renewable energy. The "Circular Economy" and "Waste" categories strongly focus on waste management and efficient use of resources. With many links and link strengths, research in this category highlights the importance of reducing waste and recycling materials to create a more sustainable energy system.
The renewable energy source category stands out with significant link strength and events, indicating that the development and use of renewable energy sources remain a top priority. Categories such as architecture and form reflect design and structural approaches in applying renewable energy technologies, which are essential for effective integration in the built environment. Additionally, the heat category highlights the focus on thermal aspects in renewable energy systems, which play an indispensable role in energy efficiency. The case study and concept categories indicate that this research also includes concrete case studies and the development of new concepts that can be applied in various contexts. It provides valuable practical and theoretical insights to accelerate the adoption of renewable energy technologies and circular economic principles. With a consistent average publication year of around 2022, this table reflects the relevance and urgency of research in this field to face increasingly complex energy and environmental challenges. Overall, this table indicates that research in Cluster V focuses on developing innovative solutions to utilise renewable energy and apply circular economy principles. This approach is essential to achieve a sustainable energy system and reduce environmental negative impacts. This analysis comprehensively shows how various design, technology, and concept aspects interact to create more efficient and environmentally friendly energy solutions.

**Table 5**. Cluster V Innovative Approaches in Renewable Energy and Circular Economy

| Id | Categories | Links | Total link strength | Occurrences | Score Average Publications/ year |
|---|---|---|---|---|---|
| 3 | Architecture | 3 | 3 | 3 | 2022 |
| 7 | Case study | 2 | 2 | 3 | 2022 |
| 9 | Circular economy | 6 | 8 | 3 | 2022 |
| 12 | Concept | 7 | 7 | 4 | 2022 |
| 25 | Form | 7 | 7 | 4 | 2022.5 |
| 27 | Heat | 4 | 5 | 3 | 2022 |
| 33 | Importance | 5 | 5 | 3 | 2022.333 |
| 38 | Order | 10 | 12 | 6 | 2022 |
| 46 | Renewable energy Source | 11 | 12 | 8 | 2022.5 |
| 64 | Waste | 12 | 17 | 7 | 2022.286 |

**Table 6** displays the results of the bibliometric analysis of Cluster VI relating to hybrid renewable energy systems and uncertainty management. The categories listed include art (Art), HRES (Hybrid Renewable Energy System), hybrid energy storage (Hybrid Energy Storage), state (State), and uncertainty (Uncertainty). Each category is assessed based on metrics such as number of links, total link strength, occurrences and average score of publications per year. This analysis shows that significant attention is being paid to developing and optimising hybrid renewable energy systems. The hybrid renewable energy system and hybrid energy storage categories strongly focus on hybrid technologies that combine various renewable energy sources with efficient energy storage solutions. With many links and link strengths, research in this category highlights the importance of hybrid technologies in achieving sustainable and reliable energy systems.
The uncertainty category highlights the challenges faced in managing uncertainty related to the availability of renewable energy sources and variability in energy demand. Research in this category is essential for developing mitigation strategies that can improve the reliability and stability of renewable energy systems. The state category focuses on the role of states and policies in supporting the development and implementation of hybrid renewable energy technologies. The Art category included in this cluster shows that there is also interest in creative and innovative approaches to the development and application of renewable energy technologies. It covers the design and integration of renewable energy systems in a broader context, including aesthetic and functional aspects. Overall, this table

indicates that research in Cluster VI focuses on combining different renewable energy technologies to create more efficient and reliable systems and manage the uncertainty associated with the variability of renewable energy sources. This analysis provides a comprehensive picture of how various hybrid technologies and uncertainty management strategies can work together to achieve sustainable energy goals and increase the stability of the global energy system.

**Table 6**. Cluster VI hybrid renewable energy systems and uncertainty management

| Id | Categories | Links | Total link strength | Occurrences | Score Average Publications/ year |
|---|---|---|---|---|---|
| 4 | Art | 5 | 9 | 4 | 2022.25 |
| 28 | Heres | 3 | 3 | 3 | 2022 |
| 30 | Hybrid energy storage | 5 | 6 | 3 | 2022 |
| 31 | Hybrid renewable energy system | 12 | 14 | 6 | 2022.167 |
| 54 | State | 8 | 12 | 9 | 2022.222 |
| 62 | Uncertainty | 7 | 7 | 6 | 2022.167 |

Based on previous research, several emerging markets for renewable energy, including hydrogen-based solutions, offer great potential in driving the clean energy transition. One important example is the market for green hydrogen produced using renewable energy such as solar or wind power [6,88,89]. Green hydrogen is recognised as a potential solution for decarbonising sectors that are difficult to supply directly with renewable energy, such as heavy industry (steel, cement), long-haul transportation, and the aviation sector. Countries like Germany, Japan, and Australia have invested significantly in green hydrogen infrastructure and are collaborating to build international hydrogen distribution networks [90–92]. In addition, the hydrogen vehicle market is also starting to grow, especially in heavy-duty vehicles and public transportation applications, where electric batteries have limitations in terms of range and efficiency. Several Asian countries, including South Korea and China, are developing hydrogen fuel cell-based vehicle technology to reduce carbon emissions in the transportation sector [93–97].

Another example is offshore wind energy, rapidly expanding into new markets, especially in Asia and South America [1,98]. Countries such as Vietnam, Taiwan, and Brazil are starting to develop sizeable offshore wind projects to tap into the abundant potential of sea wind [99–102]. Technology is a critical solution to meet the growing demand for renewable energy in regions experiencing rapid economic growth. Previous research has also shown that energy storage technologies, such as large-scale batteries, are starting to play a crucial role in emerging renewable energy markets, such as India and South Africa [103–105]. With these technologies, developing countries can more effectively integrate volatile renewable energy sources into their energy grids, thereby increasing the stability of the energy supply. Green hydrogen, offshore wind energy, and energy storage technologies are examples of rapidly growing renewable energy markets with great potential to support the worldwide clean energy transition.

This study used several statistical parameters and thresholds to identify significant trends or correlations in bibliometric data. One of the main parameters used is the minimum occurrence, where only keywords, authors, or publications that appear more than a certain number of times are included in the analysis to ensure a focus on relevant trends and not just sporadic data. For example, keywords that appear at least 5 times in publications from 2021-2023 may be considered significant for further analysis. In addition, the total link strength and co-occurrence frequency were also analysed, with a minimum threshold set to determine a strong enough connection between certain elements. Statistical analysis using Pearson correlation or regression analysis was applied to the relationship between variables, such as the number of publications and trends in a particular energy technology, to identify significant correlations. By setting these parameters, the study was able to locate genuinely significant patterns and avoid overinterpreting less relevant or randomly occurring data.

## 4. Discussion

The analysis results show that integrating advanced technologies such as artificial intelligence and hybrid energy storage is a rapidly growing research area. By managing and optimising energy systems, artificial intelligence can increase efficiency and reduce operational costs. For example, deep learning algorithms can predict energy demand patterns and optimise energy distribution from renewable sources. Effective thermal management is critical to maintaining the performance and reliability of energy storage systems and hybrid electric vehicles. Research in this area focuses on developing new materials and more efficient thermal management techniques to reduce overheating and extend the life of energy storage devices. Research also shows that the adoption of renewable energy has a significant impact on social and economic sustainability. For example, developing a circular economy that utilises renewable resources can reduce waste and emissions while creating new jobs and encouraging sustainable economic growth.

The interconnection between various concepts in bibliometric visualisation shows the importance of a multidisciplinary approach in renewable energy research. Collaboration between scientists, engineers, economists and environmental experts is needed to develop comprehensive and sustainable solutions. This research underlines that advanced technology, and innovation cannot stand alone but must be integrated with environmental and social considerations. The findings from this analysis provide directions for future research in renewable energy. A focus on incorporating advanced technologies and thermal management, as well as sustainability considerations, can help accelerate the adoption of renewable energy. This research also emphasises the need for policies that support innovation and implementation of renewable energy technologies to achieve global sustainability goals.

This bibliometric analysis fills a gap in existing literature by providing a comprehensive quantitative approach to research trends, collaboration patterns, and the impact of scholarly work in a field. While previous studies may have focused on qualitative or narrative reviews, this analysis highlights historical trends, identifies international collaboration patterns, and the impact of citation-based research that has not been widely uncovered. As such, this analysis provides new, more structured insights and helps map the development of the topic more broadly and deeply than previous approaches.

Several essential factors will heavily influence the future integration of renewable energy sources into global energy policy and infrastructure. First, advanced technologies such as energy storage systems, smart grids, and digital technologies such as AI and IoT will enable more efficient integration of renewable energy sources, such as solar and wind, into existing energy systems. These technologies will improve grid stability, allow better energy demand prediction, and increase flexibility in managing intermittent energy sources. Second, global energy policies and regulations will increasingly accelerate the adoption of renewable energy. Initiatives such as net-zero emissions targets and the transition away from fossil fuels outlined in international agreements such as the Paris Agreement encourage governments to establish regulations and incentives that facilitate the use of clean energy. In the future, policies promoting investment in renewable energy infrastructure and research related to advanced technologies will be critical drivers of the successful integration of renewable energy. Third, global energy infrastructure must be adapted to handle increasing volumes of renewable energy. This includes building more robust, intelligent transmission grids and developing large-scale energy storage systems to balance fluctuating supplies. Infrastructure designed to support flexibility and interconnection between countries will also be essential, enabling cross-border energy trade and increasing the resilience of the global energy system to disruptions. In future scenarios, proactive global policies, advanced technological innovations, and adaptive infrastructure will be vital in accelerating the transition to cleaner and more sustainable energy while ensuring the stable and efficient integration of renewable energy sources into the global energy system.

Recent research on battery technology innovation and renewable energy grid integration shows significant progress in supporting the transition to a clean energy system. In recent years, innovations in battery technology, particularly lithium-ion and solid-state batteries, have increased energy storage capacity and battery life while lowering production costs [106–109]. New studies are also exploring using more affordable sodium-based batteries and environmentally friendly materials as alternatives to lithium-ion, especially for large-scale and grid applications [110–112]. In addition, large-scale battery technologies, such as grid-tied energy storage systems, enable better integration of intermittent renewables, such as wind and solar, into the energy grid [35,113,114]. Using batteries to store energy when supply is higher than demand and release it when demand increases, grid stability and reliability can be significantly improved. Recent renewable energy grid integration research highlights applying dynamic programming techniques and intelligent optimisation algorithms to maximise grid efficiency [115–117]. These methods help in real-time decision-making for load balancing, energy storage, and renewable resource management. Dynamic programming techniques address uncertainties in renewable energy supply and variability in energy demand by calculating optimal solutions under changing conditions. In addition, smart grid technology, integrating intelligent technologies such as AI and machine learning, plays a vital role in efficiently managing renewable energy distribution [118–120]. These systems use real-time data to predict energy needs, optimise power distribution, and reduce energy waste. Combining more advanced battery technology and optimization techniques enables more effective management of renewable energy resources and improves the future power grid's stability.

In this study, bibliometric results are measured using quantitative metrics such as total link strength, which describes the strength of the relationship between elements such as keywords, publications, or authors. Total link strength measures how often these elements appear in different publications, indicating the importance or dominance of a particular theme in scientific literature. Software such as VOSviewer is used to visualise this connection network, revealing the relationships between matters such as renewable energy and energy management based on their frequency of occurrence. In addition, metrics such as citation count and h-index are used to assess the impact of publications and collaborations between authors, providing a deeper understanding of the trends, influences, and research patterns on renewable energy and advanced technologies from 2021-2023.

## 5. Future Trends and Challenges

This research will improve readability and provide a clearer understanding of the direction of renewable energy development and the challenges that may be faced in the future. In this section, the explanation of future trends can include predictions on how technological innovations, such as green hydrogen, solid-state batteries, and AI-based smart grids, will play a central role in overcoming current limitations of renewable energy, such as intermittency and energy storage. Other trends that can be highlighted are the increasing scale of offshore wind projects, the development of large-scale energy storage solutions, and the integration of renewable energy across national borders that leverage the interconnectedness of the global electricity grid to stabilise energy supplies.

On the other hand, the challenges section can include an analysis of policy barriers, such as differences in regulations across countries that hinder investment in renewable energy infrastructure or limited funding for developing new technologies, especially in developing countries. Other challenges are technical issues, such as the need for more efficient energy storage systems and potential risks to grid stability from high penetration of intermittent renewable energy. Supply chain resilience issues for renewable technology raw materials, such as rare earth metals used in batteries and solar panels, must also be considered when facing a clean energy-focused future. By dividing these trends and challenges into separate sections, readers can more easily understand the dynamics of the future of renewable energy and get a clear picture of the steps that need to be taken to overcome the challenges that will arise. This section will provide vital context for further discussion on the importance of global innovation and collaboration in achieving a sustainable energy transition.

Several countries have taken significant steps to accelerate the adoption of renewable energy, which can serve as examples for future policy developments. For example, the European Union has set an ambitious target through the European Green Deal, which aims to achieve carbon neutrality by 2050. The EU has also introduced subsidies for renewable energy, such as financing offshore wind projects, and established a carbon emissions trading system that forces industries to switch to cleaner energy sources. These policies are expected to continue to evolve by introducing more stringent mechanisms for the deterioration of the industrial and transport sectors. The United States, under the Inflation Reduction Act of 2022, has allocated hundreds of billions of dollars to encourage the development of renewable energy, including solar, wind, and green hydrogen technologies. These policies are expected to spur investment in research and development of clean energy technologies and expand the use of tax credits for renewable energy projects for decades to come. In the future, the US focus will likely shift

to developing energy storage technologies and modernising the electric grid to increase the integration of renewable energy.
In Asia, Japan and South Korea have also set ambitious targets to achieve net zero emissions by 2050, with policies encouraging the development of hydrogen technology and offshore wind projects. Japan is focused on the hydrogen economy, with significant investments in producing and distributing green hydrogen. At the same time, South Korea has introduced its Fourth Basic Energy Plan, which emphasises increasing the share of renewable energy to 30–35% by 2040. As the world's largest emitter, China has also committed to achieving carbon neutrality by 2060. It has expanded its renewable energy capacity through significant investments in solar, wind, and energy storage projects. China's Five-Year Plan focuses on reducing reliance on coal and increasing the use of clean energy. In the future, China is expected to continue to lead in the production and adoption of energy storage batteries and solar and wind energy. In addition, developing countries such as India and Brazil are also developing policies to accelerate the use of renewable energy. India has launched the National Solar Mission, aiming to achieve 100 GW of solar capacity by 2030 and incorporating energy storage technology to support its electricity grid. Meanwhile, Brazil relies on hydroelectric and wind resources, with plans to expand offshore wind projects to increase the contribution of clean energy to its energy mix.

---

## 6. Conclusion

This research uses bibliometric analysis to identify and analyse the relationships between various concepts in renewable energy, with a particular focus on integrating advanced technologies such as artificial intelligence, hybrid energy storage, and thermal management. The analysis results show a strong interconnection between these concepts, underscoring the importance of a multidisciplinary approach in renewable energy research and application. Bibliometric analysis reveals that energy storage and thermal management technologies are essential in supporting the efficiency and stability of renewable energy systems. Artificial intelligence, with applications in energy management and demand prediction, is emerging as one of the critical themes showing great potential in improving the performance and integration of renewable energy systems. In addition, this research highlights the importance of hybrid electric vehicles and fuel cell technology in reducing emissions and supporting transportation sustainability. This research also shows that the concepts of sustainability, climate change mitigation, and circular economy are the focus of renewable energy research. The close relationship between these concepts shows that renewable energy technologies are essential not only from a technical point of view but also from an economic and social perspective. The keyword network visualisation shows how various research fields are interconnected and support each other in efforts to achieve energy sustainability.
This study highlights the unique contribution of integrating advanced technologies, such as artificial intelligence (AI) and hybrid energy storage, which provide new insights into renewable energy management. AI enables the analysis of large amounts of data and more thoughtful decision-making, which is especially beneficial for managing energy from volatile renewable sources, such as solar and wind. This technology enables energy systems to predict consumption patterns, optimize storage, and adjust energy distribution in real time. This improves the overall efficiency and stability of the system. On the other hand, hybrid energy storage technology addresses the variability of renewable energy production by combining different types of storage, thus ensuring a more stable and reliable energy supply. The integration of AI in hybrid storage systems allows for more efficient monitoring and control of the storage process, where AI can determine the optimal time to store or release energy based on the needs of the electricity grid. This combination of AI and hybrid storage reduces operational costs and improves sustainability by minimizing energy waste and supporting the transition to clean energy. Thus, this study shows how integrating these advanced technologies can be an innovative solution to the challenges of renewable energy management, increasing flexibility and efficiency and contributing to climate change mitigation.
The novelty of this research lies in a holistic approach that combines bibliometric analysis with a focus on integrating advanced technologies in renewable energy. These findings provide valuable insights for policymakers, researchers, and practitioners in developing strategies to accelerate the effective and efficient adoption and integration of renewable energy. This research also contributes to the literature

by mapping the latest trends and critical relationships in the field of renewable energy. This study confirms that advanced technologies such as artificial intelligence, hybrid energy storage, and thermal management are crucial in achieving energy sustainability. By understanding the dynamics of the interconnection between these various concepts, more effective strategies can be developed to encourage innovation and implementation of renewable energy, which will ultimately help reduce the impacts of climate change and achieve global sustainability goals.

---

## References


[1] Erdiwansyah, R. Mamat, M.S.M. Sani, K. Sudhakar, Renewable energy in Southeast Asia: Policies and recommendations, Sci. Total Environ. (2019). https://doi.org/https://doi.org/10.1016/j.scitotenv.2019.03.273.

[2] L. Shi, C. Duanmu, F. Wu, S. He, K.Y. Lee, Optimal allocation of energy storage capacity for hydro-wind-solar multi-energy renewable energy system with nested multiple time scales, J. Clean. Prod. 446 (2024) 141357. https://doi.org/https://doi.org/10.1016/j.jclepro.2024.141357.

[3] A. Gani, Erdiwansyah, E. Munawar, Mahidin, R. Mamat, S.M. Rosdi, Investigation of the potential biomass waste source for biocoke production in Indonesia: A review, Energy Reports. 10 (2023) 2417–2438. https://doi.org/https://doi.org/10.1016/j.egyr.2023.09.065.

[4] H. Wu, S.R. West, Co-optimisation of wind and solar energy and intermittency for renewable generator site selection, Heliyon. 10 (2024) e26891. https://doi.org/https://doi.org/10.1016/j.heliyon.2024.e26891.

[5] E. Erdiwansyah, M. Mahidin, H. Husin, N. Nasaruddin, K. Khairil, M. Zaki, J. Jalaluddin, Investigation of availability, demand, targets, and development of renewable energy in 2017–2050: a case study in Indonesia, Int. J. Coal Sci. Technol. 8 (2021) 1–17. https://doi.org/https://doi.org/10.1007/s40789-020-00391-4.

[6] Q. Hassan, A.K. Nassar, A.K. Al-Jiboory, P. Viktor, A.A. Telba, E.M. Awwad, A. Amjad, H.F. Fakhruldeen, S. Algburi, S.C. Mashkoor, M. Jaszczur, A.Z. Sameen, M. Barakat, Mapping Europe renewable energy landscape: Insights into solar, wind, hydro, and green hydrogen production, Technol. Soc. 77 (2024) 102535. https://doi.org/https://doi.org/10.1016/j.techsoc.2024.102535.

[7] R. Nepal, Y. Liu, J. Wang, K. Dong, How does green finance promote renewable energy technology innovation? A quasi-natural experiment perspective, Energy Econ. 134 (2024) 107576. https://doi.org/https://doi.org/10.1016/j.eneco.2024.107576.

[8] C. Zhao, J. Wang, K. Dong, K. Wang, Is renewable energy technology innovation an excellent strategy for reducing climate risk? The case of China, Renew. Energy. 223 (2024) 120042. https://doi.org/https://doi.org/10.1016/j.renene.2024.120042.

[9] S. Chen, Renewable energy technology innovation and urbanization: Insights from China, Sustain. Cities Soc. 102 (2024) 105241. https://doi.org/https://doi.org/10.1016/j.scs.2024.105241.

[10] B. Lin, A. Zhang, Digital finance, regional innovation environment and renewable energy technology innovation: Threshold effects, Renew. Energy. 223 (2024) 120036. https://doi.org/https://doi.org/10.1016/j.renene.2024.120036.

[11] K. Jin, Y. Li, H. Wu, Y.C. Tham, V. Koh, Y. Zhao, R. Kawasaki, A. Grzybowski, J. Ye, Integration of smartphone technology and artificial intelligence for advanced ophthalmic care: A systematic review, Adv. Ophthalmol. Pract. Res. 4 (2024) 120–127. https://doi.org/https://doi.org/10.1016/j.aopr.2024.03.003.

[12] H. Shi, A. Kowalczewski, D. Vu, X. Liu, A. Salekin, H. Yang, Z. Ma, Organoid intelligence: Integration of organoid technology and artificial intelligence in the new era of in vitro models, Med. Nov. Technol. Devices. 21 (2024) 100276. https://doi.org/https://doi.org/10.1016/j.medntd.2023.100276.

[13] Y. Yang, H. Xin, Y. Liu, H. Cheng, Y. Jin, C. Li, J. Lu, B. Fang, Z. Hong, X. Jing, Intelligent metasurfaces: Integration of artificial intelligence technology and metasurfaces, Chinese J. Phys. 89 (2024) 991–1008. https://doi.org/https://doi.org/10.1016/j.cjph.2024.03.043.

[14] J.F. Wolfaardt, L.E. Brecht, R.M. Taft, G.T. Grant, The future of maxillofacial prosthodontics

in North America: The role of advanced digital technology and artificial intelligence – A discussion document, J. Prosthet. Dent. (2024). https://doi.org/https://doi.org/10.1016/j.prosdent.2024.03.016.
[15] A. Gani, S. Saisa, M. Muhtadin, B. Bahagia, E. Erdiwansyah, Y. Lisafitri, Optimisation of home grid-connected photovoltaic systems: performance analysis and energy implications, Int. J. Eng. Technol. 1 (2025) 63–74.
[16] Z. Medghalchi, O. Taylan, A novel hybrid optimization framework for sizing renewable energy systems integrated with energy storage systems with solar photovoltaics, wind, battery and electrolyzer-fuel cell, Energy Convers. Manag. 294 (2023) 117594. https://doi.org/https://doi.org/10.1016/j.enconman.2023.117594.
[17] Y.W. Koholé, C.A. Wankouo Ngouleu, F.C.V. Fohagui, G. Tchuen, A comprehensive comparison of battery, hydrogen, pumped-hydro and thermal energy storage technologies for hybrid renewable energy systems integration, J. Energy Storage. 93 (2024) 112299. https://doi.org/https://doi.org/10.1016/j.est.2024.112299.
[18] H. Rezk, A. Fathy, Hydrogen reduction-based energy management strategy of hybrid fuel cell/PV/battery/supercapacitor renewable energy system, J. Energy Storage. 86 (2024) 111316. https://doi.org/https://doi.org/10.1016/j.est.2024.111316.
[19] R. Gugulothu, B. Nagu, D. Pullaguram, Energy management strategy for standalone DC microgrid system with photovoltaic/fuel cell/battery storage, J. Energy Storage. 57 (2023) 106274. https://doi.org/https://doi.org/10.1016/j.est.2022.106274.
[20] Y. Qi, J. Lu, T. Liu, Measuring energy transition away from fossil fuels: A new index, Renew. Sustain. Energy Rev. 200 (2024) 114546. https://doi.org/https://doi.org/10.1016/j.rser.2024.114546.
[21] Y.K. Hwang, Á. Sánchez Díez, Renewable energy transition and green growth nexus in Latin America, Renew. Sustain. Energy Rev. 198 (2024) 114431. https://doi.org/https://doi.org/10.1016/j.rser.2024.114431.
[22] S.A. Neves, A.C. Marques, The substitution of fossil fuels in the US transportation energy mix: Are emissions decoupling from economic growth?, Res. Transp. Econ. 90 (2021) 101036. https://doi.org/https://doi.org/10.1016/j.retrec.2021.101036.
[23] H. Khurshid, B.S. Mohammed, A.M. Al-Yacouby, M.S. Liew, N.A.W.A. Zawawi, Analysis of hybrid offshore renewable energy sources for power generation: A literature review of hybrid solar, wind, and waves energy systems, Dev. Built Environ. 19 (2024) 100497. https://doi.org/https://doi.org/10.1016/j.dibe.2024.100497.
[24] J. Jurasz, P.B. Dąbek, B. Kaźmierczak, A. Kies, M. Wdowikowski, Large scale complementary solar and wind energy sources coupled with pumped-storage hydroelectricity for Lower Silesia (Poland), Energy. 161 (2018) 183–192. https://doi.org/https://doi.org/10.1016/j.energy.2018.07.085.
[25] A. Javaid, M. Sajid, E. Uddin, A. Waqas, Y. Ayaz, Sustainable urban energy solutions: Forecasting energy production for hybrid solar-wind systems, Energy Convers. Manag. 302 (2024) 118120. https://doi.org/https://doi.org/10.1016/j.enconman.2024.118120.
[26] A. Gani, M. Zaki, B. Bahagia, G. Maghfirah, M. Faisal, Characterization of Porosity and Pore Volume in EFB Samples through Physical and Morphological Parameters, Int. J. Eng. Technol. 1 (2025) 90–99.
[27] Q. Hassan, S. Algburi, A.Z. Sameen, H.M. Salman, M. Jaszczur, A review of hybrid renewable energy systems: Solar and wind-powered solutions: Challenges, opportunities, and policy implications, Results Eng. 20 (2023) 101621. https://doi.org/https://doi.org/10.1016/j.rineng.2023.101621.
[28] C.M.S. Kumar, S. Singh, M.K. Gupta, Y.M. Nimdeo, R. Raushan, A. V Deorankar, T.M.A. Kumar, P.K. Rout, C.S. Chanotiya, V.D. Pakhale, A.D. Nannaware, Solar energy: A promising renewable source for meeting energy demand in Indian agriculture applications, Sustain. Energy Technol. Assessments. 55 (2023) 102905. https://doi.org/https://doi.org/10.1016/j.seta.2022.102905.
[29] M.G. Gebreslassie, Development and manufacturing of solar and wind energy technologies in Ethiopia: Challenges and policy implications, Renew. Energy. 168 (2021) 107–118. https://doi.org/https://doi.org/10.1016/j.renene.2020.11.042.

[30] P. Selvakumar, A. Gani, J. Xiaoxia, M.R. Salleh, Porosity and Pore Volume Analysis of EFB Fiber: Physical Characterization and Effect of Thermal Treatment, Int. J. Eng. Technol. 1 (2025) 100–108.
[31] H. Mengi-Dinçer, V.Ş. Ediger, Ç.G. Yesevi, Evaluating the International Renewable Energy Agency through the lens of social constructivism, Renew. Sustain. Energy Rev. 152 (2021) 111705. https://doi.org/https://doi.org/10.1016/j.rser.2021.111705.
[32] G. Wright, The International Renewable Energy Agency: A Global Voice for the Renewable Energy Era?, Renew. Energy L. Pol'y Rev. 2 (2011) 251.
[33] R.E.S. IRENA, International renewable energy agency, Abu Dhabi. 2020 (2020).
[34] M. Muhibbuddin, M.A. Hamidi, D.F. Fitriyana, Bibliometric Analysis of Renewable Energy Technologies Using VOSviewer: Mapping Innovations and Applications, Int. J. Sci. Adv. Technol. 1 (2025) 81–91.
[35] M. Khalid, Smart grids and renewable energy systems: Perspectives and grid integration challenges, Energy Strateg. Rev. 51 (2024) 101299. https://doi.org/https://doi.org/10.1016/j.esr.2024.101299.
[36] A. Raza, M. Liaqat, M. Adnan, M.S. Iqbal, L. Jingzhao, I. Ahmad, SAARC super smart grid: Navigating the future - unleashing the power of an energy-efficient integration of renewable energy resources in the saarc region, Comput. Electr. Eng. 118 (2024) 109405. https://doi.org/https://doi.org/10.1016/j.compeleceng.2024.109405.
[37] B. Gudlaugsson, T.G. Ahmed, H. Dawood, C. Ogwumike, M. Short, N. Dawood, Cost and environmental benefit analysis: An assessment of renewable energy integration and smart solution technologies in the InteGRIDy project, Clean. Energy Syst. 5 (2023) 100071. https://doi.org/https://doi.org/10.1016/j.cles.2023.100071.
[38] D.F. Fitriyana, R. Rusiyanto, W. Maawa, Renewable Energy Application Research Using VOSviewer software: Bibliometric Analysis, Int. J. Sci. Adv. Technol. 1 (2025) 92–107.
[39] S. Nyamathulla, C. Dhanamjayulu, A review of battery energy storage systems and advanced battery management system for different applications: Challenges and recommendations, J. Energy Storage. 86 (2024) 111179. https://doi.org/https://doi.org/10.1016/j.est.2024.111179.
[40] Z. Ullah, H.S. Qazi, A.U. Rehman, H.M. Hasanien, S. Wang, M.R. Elkadeem, F. Badshah, Efficient energy management of domestic loads with electric vehicles by optimal scheduling of solar-powered battery energy storage system, Electr. Power Syst. Res. 234 (2024) 110570. https://doi.org/https://doi.org/10.1016/j.epsr.2024.110570.
[41] R. Huang, S. Luo, Q. Sun, S. Yan, Insights on energy storage mechanism and rational design of chalcogenide-based cathode materials towards advanced non-aqueous Al-ion batteries, J. Energy Storage. 93 (2024) 112384. https://doi.org/https://doi.org/10.1016/j.est.2024.112384.
[42] S.M. Rosdi, G. Maghfirah, E. Erdiwansyah, S. Syafrizal, M. Muhibbuddin, Bibliometric Study of Renewable Energy Technology Development: Application of VOSviewer in Identifying Global Trends, Int. J. Sci. Adv. Technol. 1 (2025) 71–80.
[43] M. Nizar, S. Syafrizal, A.-F. Zikrillah, A. Rahman, A.E. Hadi, H. Pranoto, Optimizing Waste Transport Efficiency in Langsa City, Indonesia: A Dynamic Programming Approach, Int. J. Sci. Adv. Technol. 1 (2025) 10–17.
[44] X. Yang, A. Abdin, J. Puchinger, Optimal management of coupled shared autonomous electric vehicles and power grids: Potential of renewable energy integration, Transp. Res. Part C Emerg. Technol. 165 (2024) 104726. https://doi.org/https://doi.org/10.1016/j.trc.2024.104726.
[45] M.I. Saleem, S. Saha, T.K. Roy, A frequency stability assessment framework for renewable energy rich power grids, Sustain. Energy, Grids Networks. 38 (2024) 101380. https://doi.org/https://doi.org/10.1016/j.segan.2024.101380.
[46] H. Pishbahar, F. Blaabjerg, H. Saboori, Emerging grid-forming power converters for renewable energy and storage resources integration – A review, Sustain. Energy Technol. Assessments. 60 (2023) 103538. https://doi.org/https://doi.org/10.1016/j.seta.2023.103538.
[47] C.-C. Chang, K.-C. Chang, Y.-L. Lin, Policies for reducing the greenhouse gas emissions generated by the road transportation sector in Taiwan, Energy Policy. 191 (2024) 114171. https://doi.org/https://doi.org/10.1016/j.enpol.2024.114171.
[48] K. Jia, R. Yuan, The impact of basin horizontal ecological compensation policies on carbon emissions: A case study of the Yangtze river economic Belt, Heliyon. 10 (2024) e28858.

https://doi.org/https://doi.org/10.1016/j.heliyon.2024.e28858.
[49] Y. Xu, C. Liu, F. Wei, S. Zhao, H. Mao, The influence of government subsidies on remanufacturers' production decisions, considering product quality, customer purchase intention, and carbon emissions, J. Clean. Prod. 443 (2024) 141130. https://doi.org/https://doi.org/10.1016/j.jclepro.2024.141130.
[50] K. Wang, Y. Qiao, L. Ling, Z. Zhao, K. Liu, The impact of carbon emissions trading policy on carbon emission efficiency in Chinese cities: Evidence from a quasi-natural experiment, Chinese J. Popul. Resour. Environ. 21 (2023) 121–136. https://doi.org/https://doi.org/10.1016/j.cjpre.2023.09.001.
[51] Z. Xiao, Y. Chen, D. Wang, H. Liu, Y. Liu, M. Gao, J. Fan, Performance analysis of photovoltaic residual electricity thermal conversion and storage system in solar energy enrichment areas, Sol. Energy. 274 (2024) 112562. https://doi.org/https://doi.org/10.1016/j.solener.2024.112562.
[52] Z. Qu, C. Xu, F. Yang, F. Ling, S. Pirouzi, Market clearing price-based energy management of grid-connected renewable energy hubs including flexible sources according to thermal, hydrogen, and compressed air storage systems, J. Energy Storage. 69 (2023) 107981. https://doi.org/https://doi.org/10.1016/j.est.2023.107981.
[53] H. Liang, S. Pirouzi, Energy management system based on economic Flexi-reliable operation for the smart distribution network including integrated energy system of hydrogen storage and renewable sources, Energy. 293 (2024) 130745. https://doi.org/https://doi.org/10.1016/j.energy.2024.130745.
[54] E. Nivolianiti, Y.L. Karnavas, J.-F. Charpentier, Energy management of shipboard microgrids integrating energy storage systems: A review, Renew. Sustain. Energy Rev. 189 (2024) 114012. https://doi.org/https://doi.org/10.1016/j.rser.2023.114012.
[55] H. Pranoto, R. Rusiyanto, D.F. Fitriyana, Sustainable Wastewater Management in Sumedang: Design, Treatment Technologies, and Resource Recovery, Int. J. Sci. Adv. Technol. 1 (2025) 38–46.
[56] B.H. Yiğit, M.İ. Karamangil, Selection powertrain for 25 m bi-articulated series hybrid, electric or fuel cell vehicle operating on Istanbul Bus Rapid Transit Line, Eng. Sci. Technol. an Int. J. 54 (2024) 101719. https://doi.org/https://doi.org/10.1016/j.jestch.2024.101719.
[57] S.F. da Silva, J.J. Eckert, F.L. Silva, F.C. Corrêa, L.C.A. Silva, A.V. Bueno, F.G. Dedini, Aging-aware optimal power management control and component sizing of a fuel cell hybrid electric vehicle powertrain, Energy Convers. Manag. 292 (2023) 117330. https://doi.org/https://doi.org/10.1016/j.enconman.2023.117330.
[58] M. Asli, P. König, D. Sharma, E. Pontika, J. Huete, K.R. Konda, A. Mathiazhagan, T. Xie, K. Höschler, P. Laskaridis, Thermal management challenges in hybrid-electric propulsion aircraft, Prog. Aerosp. Sci. 144 (2024) 100967. https://doi.org/https://doi.org/10.1016/j.paerosci.2023.100967.
[59] S. Kharabati, S. Saedodin, A systematic review of thermal management techniques for electric vehicle batteries, J. Energy Storage. 75 (2024) 109586. https://doi.org/https://doi.org/10.1016/j.est.2023.109586.
[60] Y.-G. Lv, Y.Y.-G. Lv, Y.-T. Wang, T. Meng, Q.-W. Wang, W.-X. Chu, Review on Thermal Management Technologies for Electronics in Spacecraft Environment, Energy Storage Sav. (2024). https://doi.org/https://doi.org/10.1016/j.enss.2024.03.001.
[61] J. Marić, M. Opazo-Basáez, B. Vlačić, M. Dabić, Innovation management of three-dimensional printing (3DP) technology: Disclosing insights from existing literature and determining future research streams, Technol. Forecast. Soc. Change. 193 (2023) 122605. https://doi.org/https://doi.org/10.1016/j.techfore.2023.122605.
[62] X. Liu, Z. Zhang, C. Zhu, F. Wang, D. Zhao, Z. Li, Y. Liu, H. Zhang, H. Jiang, Experimental investigation on the effect of phase change materials for thermal management improvement of the fast charging power module, Case Stud. Therm. Eng. 42 (2023) 102711. https://doi.org/https://doi.org/10.1016/j.csite.2023.102711.
[63] C. Qin, P. Song, X. Sun, R. Wang, M. Wei, M. Mao, Actuation technique of liquid metal in thermal management: A review, Appl. Therm. Eng. 248 (2024) 123290. https://doi.org/https://doi.org/10.1016/j.applthermaleng.2024.123290.
[64] A.A. Mufti, I. Irhamni, Y. Darnas, Exploration of predictive models in optimising renewable

energy integration in grid systems, Int. J. Sci. Adv. Technol. 1 (2025) 47–61.
[65] T.A. Kurniawan, C. Meidiana, H.H. Goh, D. Zhang, M.H.D. Othman, F. Aziz, A. Anouzla, P.K. Sarangi, B. Pasaribu, I. Ali, Unlocking synergies between waste management and climate change mitigation to accelerate decarbonization through circular-economy digitalization in Indonesia, Sustain. Prod. Consum. 46 (2024) 522–542. https://doi.org/https://doi.org/10.1016/j.spc.2024.03.011.
[66] M.X. Paes, J.A. Puppim de Oliveira, S.D. Mancini, J. Rieradevall, Waste management intervention to boost circular economy and mitigate climate change in cities of developing countries: The case of Brazil, Habitat Int. 143 (2024) 102990. https://doi.org/https://doi.org/10.1016/j.habitatint.2023.102990.
[67] P. McKenna, F. Zakaria, J. Guest, B. Evans, S. Banwart, Will the circle be unbroken? The climate mitigation and sustainable development given by a circular economy of carbon, nitrogen, phosphorus and water††Electronic supplementary information (ESI) available. See DOI: https://doi.org/10.1039/d2su00121g, RSC Sustain. 1 (2023) 960–974. https://doi.org/https://doi.org/10.1039/d2su00121g.
[68] G.E. Dumitran, L.I. Vuta, E. Negrusa, A.-C. Birdici, Reducing greenhouse gas emissions in Romanian agriculture using renewable energy sources, J. Clean. Prod. 467 (2024) 142918. https://doi.org/https://doi.org/10.1016/j.jclepro.2024.142918.
[69] S. Tauseef Hassan, Danish, M. Awais Baloch, Q. Bui, N. Hashim Khan, The heterogeneous impact of geopolitical risk and environment-related innovations on greenhouse gas emissions: The role of nuclear and renewable energy in the circular economy, Gondwana Res. 127 (2024) 144–155. https://doi.org/https://doi.org/10.1016/j.gr.2023.08.016.
[70] Y. Dong, W.-K. Wong, I. Muda, P.T. Cong, A. Duong Hoang, W. Ghardallou, N.N. Ha, Do natural resources utilization and economic development reduce greenhouse gas emissions through consuming renewable and Clean Technology? A case study of China towards sustainable development goals, Resour. Policy. 85 (2023) 103921. https://doi.org/https://doi.org/10.1016/j.resourpol.2023.103921.
[71] M.K. Biswas, A.K. Azad, A. Datta, S. Dutta, S. Roy, S.S. Chopra, Navigating Sustainability through Greenhouse Gas Emission Inventory: ESG Practices and Energy Shift in Bangladesh's Textile and Readymade Garment Industries, Environ. Pollut. 345 (2024) 123392. https://doi.org/https://doi.org/10.1016/j.envpol.2024.123392.
[72] Y. Geng, Q. Xiang, N. Zhang, J. Gao, Y. Yan, Bibliometric Analysis of Microgrid Control Strategy from 2007 to 2022 Based on CiteSpace, Electr. Power Components Syst. (2024) 1–31.
[73] A. Zaidi, A bibliometric analysis of machine learning techniques in photovoltaic cells and solar energy (2014–2022), Energy Reports. 11 (2024) 2768–2779. https://doi.org/https://doi.org/10.1016/j.egyr.2024.02.036.
[74] C.H.E.W.A.N.M. NOOR, F. Arif, D. Rusirawan, Optimising Engine Performance and Emission Characteristics Through Advanced Simulation Techniques, Int. J. Simulation, Optim. Model. 1 (2025) 10–20.
[75] I. Iqbal, S.M. Rosdi, M. Muhtadin, E. Erdiwansyah, M. Faisal, Optimisation of combustion parameters in turbocharged engines using computational fluid dynamics modelling, Int. J. Simulation, Optim. Model. 1 (2025) 63–69.
[76] A. Entezari, A. Aslani, R. Zahedi, Y. Noorollahi, Artificial intelligence and machine learning in energy systems: A bibliographic perspective, Energy Strateg. Rev. 45 (2023) 101017. https://doi.org/https://doi.org/10.1016/j.esr.2022.101017.
[77] R.I. Mukhamediev, Y. Popova, Y. Kuchin, E. Zaitseva, A. Kalimoldayev, A. Symagulov, V. Levashenko, F. Abdoldina, V. Gopejenko, K. Yakunin, Review of artificial intelligence and machine learning technologies: classification, restrictions, opportunities and challenges, Mathematics. 10 (2022) 2552.
[78] H.A. Jalaludin, M.K. Kamarulzaman, A. Sudrajad, S.M. Rosdi, E. Erdiwansyah, Engine Performance Analysis Based on Speed and Throttle Through Simulation, Int. J. Simulation, Optim. Model. 1 (2025) 86–93.
[79] H. Lund, P.A. Østergaard, D. Connolly, B.V. Mathiesen, Smart energy and smart energy systems, Energy. 137 (2017) 556–565.
[80] I.A. Rana, Disaster and climate change resilience: A bibliometric analysis, Int. J. Disaster Risk

Reduct. 50 (2020) 101839. https://doi.org/https://doi.org/10.1016/j.ijdrr.2020.101839.
[81] H. Chen, T.N. Cong, W. Yang, C. Tan, Y. Li, Y. Ding, Progress in electrical energy storage system: A critical review, Prog. Nat. Sci. 19 (2009) 291–312.
[82] M. Muhtadin, S.M. Rosdi, M. Faisal, E. Erdiwansyah, M. Mahyudin, Analysis of NOx, HC, and CO Emission Prediction in Internal Combustion Engines by Statistical Regression and ANOVA Methods, Int. J. Simulation, Optim. Model. 1 (2025) 94–102.
[83] M.A. Rosli, J. Xiaoxia, Z. Shuai, Machine Learning-Driven Optimisation of Aerodynamic Designs for High-Performance Vehicles, Int. J. Simulation, Optim. Model. 1 (2025) 43–53.
[84] M. Yasar, S. Anis, R. Rusiyanto, F.R. Yamali, Improving Farmers' Welfare through Empty Fruit Bunch-Based Product Diversification in Oil Palm Plantation Areas, Int. J. Community Serv. 1 (2025) 29–38.
[85] Y. Muchlis, I. Iqbal, T. Rahardjo, Education and Implementation of Community-Based Waste Management to Reduce Heavy Metal Pollution, Int. J. Community Serv. 1 (2025) 39–47.
[86] M. Nizar, M. Muhibbuddin, W. Maawa, Community Empowerment through the Utilization of Agricultural Waste as Environmentally Friendly Biocoke Fuel, Int. J. Community Serv. 1 (2025) 10–18.
[87] S. Yana, N. Nelly, R. Radhiana, F. Hanum, P. Mauliza, Optimization of On-Grid Microgrid Systems for Rural Communities to Increase Energy Resilience, Int. J. Community Serv. 1 (2025) 19–29.
[88] L. Al-Ghussain, A.D. Ahmad, A.M. Abubaker, M.A. Hassan, Exploring the feasibility of green hydrogen production using excess energy from a country-scale 100% solar-wind renewable energy system, Int. J. Hydrogen Energy. 47 (2022) 21613–21633. https://doi.org/https://doi.org/10.1016/j.ijhydene.2022.04.289.
[89] A.H. Schrotenboer, A.A.T. Veenstra, M.A.J. uit het Broek, E. Ursavas, A Green Hydrogen Energy System: Optimal control strategies for integrated hydrogen storage and power generation with wind energy, Renew. Sustain. Energy Rev. 168 (2022) 112744. https://doi.org/https://doi.org/10.1016/j.rser.2022.112744.
[90] V. Vijayakumar, L. Fulton, M. Shams, D. Sperling, Creating a global hydrogen economy: review of international strategies, targets, and policies with a focus on Japan, Germany, South Korea, and California, (2022).
[91] R. Quitzow, A. Nunez, A. Marian, Positioning Germany in an international hydrogen economy: A policy review, Energy Strateg. Rev. 53 (2024) 101361. https://doi.org/https://doi.org/10.1016/j.esr.2024.101361.
[92] N. Wolf, L. Kühn, M. Höck, International supply chains for a hydrogen ramp-up: Techno-economic assessment of hydrogen transport routes to Germany, Energy Convers. Manag. X. 23 (2024) 100682. https://doi.org/https://doi.org/10.1016/j.ecmx.2024.100682.
[93] Z. Abdullah, A.R. Keeley, T.Y. Coulibaly, S. Managi, The impact of fuel cell vehicles deployment on road transport greenhouse gas emissions through 2050: Evidence from 15 G20 countries, J. Environ. Manage. 370 (2024) 122660. https://doi.org/https://doi.org/10.1016/j.jenvman.2024.122660.
[94] F. Liu, F. Zhao, Z. Liu, H. Hao, The impact of fuel cell vehicle deployment on road transport greenhouse gas emissions: The China case, Int. J. Hydrogen Energy. 43 (2018) 22604–22621. https://doi.org/https://doi.org/10.1016/j.ijhydene.2018.10.088.
[95] F. Liu, D.L. Mauzerall, F. Zhao, H. Hao, Deployment of fuel cell vehicles in China: Greenhouse gas emission reductions from converting the heavy-duty truck fleet from diesel and natural gas to hydrogen, Int. J. Hydrogen Energy. 46 (2021) 17982–17997. https://doi.org/https://doi.org/10.1016/j.ijhydene.2021.02.198.
[96] M.I. Maulana, R. Febrina, F.R. Yamali, Strategy for Strengthening the Local Economy through Renewable Energy-Based Micro Enterprises in Rural Communities, Int. J. Community Serv. 1 (2025) 48–56.
[97] N. Nelly, S. Yana, R. Radhiana, J. Juwita, E. Surya, Implementation of SWOT Analysis in the Development of Green Energy-Based Social Businesses in Local Communities, Int. J. Community Serv. 1 (2025) 57–67.
[98] M.A.J.R. Quirapas, A. Taeihagh, Ocean renewable energy development in Southeast Asia: Opportunities, risks and unintended consequences, Renew. Sustain. Energy Rev. 137 (2021)

110403. https://doi.org/https://doi.org/10.1016/j.rser.2020.110403.
[99] M. Ha-Duong, S. Teske, D. Pescia, M. Pujantoro, Planning, Policy and Integration for Sustainable Development of Offshore Wind Energy in Vietnam 2022–2030, in: Proc. 2nd Vietnam Symp. Adv. Offshore Eng. Sustain. Energy Mar. Plan., Springer, 2022: pp. 48–66.
[100] M. Swadi, D. Jasim Kadhim, M. Salem, F. Mohammed Tuaimah, A.S. Majeed, A. Jawad Alrubaie, Investigating and predicting the role of photovoltaic, wind, and hydrogen energies in sustainable global energy evolution, Glob. Energy Interconnect. 7 (2024) 429–445. https://doi.org/https://doi.org/10.1016/j.gloei.2024.08.009.
[101] T.N. Do, P.J. Burke, H.N. Nguyen, I. Overland, B. Suryadi, A. Swandaru, Z. Yurnaidi, Vietnam's solar and wind power success: Policy implications for the other ASEAN countries, Energy Sustain. Dev. 65 (2021) 1–11. https://doi.org/https://doi.org/10.1016/j.esd.2021.09.002.
[102] R. Febrina, R.E. Sardjono, F. Khoerunnisa, R.R. Dirgarini, P. Selvakumar, Strengthening Local Livelihoods through the Circular Economy: Agricultural Waste Utilization for Green Energy, Int. J. Community Serv. 1 (2025) 88–95.
[103] S. Sridhar, S.R. Salkuti, Development and future scope of renewable energy and energy storage systems, Smart Cities. 5 (2022) 668–699.
[104] S.B. Sani, P. Celvakumaran, V.K. Ramachandaramurthy, S. Walker, B. Alrazi, Y.J. Ying, N.Y. Dahlan, M.H.A. Rahman, Energy storage system policies: Way forward and opportunities for emerging economies, J. Energy Storage. 32 (2020) 101902.
[105] S. Koohi-Kamali, V. V Tyagi, N.A. Rahim, N.L. Panwar, H. Mokhlis, Emergence of energy storage technologies as the solution for reliable operation of smart power systems: A review, Renew. Sustain. Energy Rev. 25 (2013) 135–165.
[106] M.D. Ahmed, K.M. Maraz, Revolutionizing energy storage: Overcoming challenges and unleashing the potential of next generation Lithium-ion battery technology, Mater. Eng. Res. 5 (2023) 265–278.
[107] W. Zaman, K.B. Hatzell, Processing and manufacturing of next generation lithium-based all solid-state batteries, Curr. Opin. Solid State Mater. Sci. 26 (2022) 101003. https://doi.org/https://doi.org/10.1016/j.cossms.2022.101003.
[108] T. Chen, X. Lai, F. Chen, Y. Wang, X. Han, Y. Zheng, Empowering lithium-ion battery manufacturing with big data: Current status, challenges, and future, J. Power Sources. 623 (2024) 235400. https://doi.org/https://doi.org/10.1016/j.jpowsour.2024.235400.
[109] D. Weitze, F.M. Zanotto, D.Z. Dominguez, A.A. Franco, Simulating solid-state battery cathode manufacturing via wet-processing with resolved active material geometries, Energy Storage Mater. 73 (2024) 103747. https://doi.org/https://doi.org/10.1016/j.ensm.2024.103747.
[110] R. Wanison, W.N.H. Syahputra, N. Kammuang-lue, P. Sakulchangsatjatai, C. Chaichana, V.U. Shankar, P. Suttakul, Y. Mona, Engineering aspects of sodium-ion battery: An alternative energy device for Lithium-ion batteries, J. Energy Storage. 100 (2024) 113497. https://doi.org/https://doi.org/10.1016/j.est.2024.113497.
[111] E. Batuecas, C.S. Martínez-Cisneros, D. Serrano, A. Várez, Life cycle assessment of lab-scale solid sodium-ion batteries: A sustainable alternative to liquid lithium-ion batteries, J. Energy Storage. 80 (2024) 110355. https://doi.org/https://doi.org/10.1016/j.est.2023.110355.
[112] T. AlHazaimeh, M. Raheem, A. Al-Othman, Covalent Organic Frameworks (COFs): Characteristics and Applications for Lithium-Ion Batteries (LIBs) and Sodium Ion Batteries (SIBs), Int. J. Thermofluids. 21 (2024) 100531. https://doi.org/https://doi.org/10.1016/j.ijft.2023.100531.
[113] G.G. Farivar, W. Manalastas, H.D. Tafti, S. Ceballos, A. Sanchez-Ruiz, E.C. Lovell, G. Konstantinou, C.D. Townsend, M. Srinivasan, J. Pou, Grid-connected energy storage systems: State-of-the-art and emerging technologies, Proc. IEEE. 111 (2022) 397–420.
[114] Z. Liao, J. Kally, S. Ru, Probabilistic modeling of renewable energy sources in smart grids: A stochastic optimization perspective, Sustain. Cities Soc. 109 (2024) 105522. https://doi.org/https://doi.org/10.1016/j.scs.2024.105522.
[115] A.U. Rehman, Z. Wadud, R.M. Elavarasan, G. Hafeez, I. Khan, Z. Shafiq, H.H. Alhelou, An optimal power usage scheduling in smart grid integrated with renewable energy sources for energy management, IEEE Access. 9 (2021) 84619–84638.
[116] D.K. Panda, S. Das, Smart grid architecture model for control, optimization and data analytics

of future power networks with more renewable energy, J. Clean. Prod. 301 (2021) 126877. https://doi.org/https://doi.org/10.1016/j.jclepro.2021.126877.

[117] H. Song, C. Liu, A.M. Amani, M. Gu, M. Jalili, L. Meegahapola, X. Yu, G. Dickeson, Smart optimization in battery energy storage systems: An overview, Energy AI. 17 (2024) 100378. https://doi.org/https://doi.org/10.1016/j.egyai.2024.100378.

[118] O. Das, M.H. Zafar, F. Sanfilippo, S. Rudra, M.L. Kolhe, Advancements in digital twin technology and machine learning for energy systems: A comprehensive review of applications in smart grids, renewable energy, and electric vehicle optimisation, Energy Convers. Manag. X. 24 (2024) 100715. https://doi.org/https://doi.org/10.1016/j.ecmx.2024.100715.

[119] M.A. Judge, V. Franzitta, D. Curto, A. Guercio, G. Cirrincione, H.A. Khattak, A Comprehensive Review of Artificial Intelligence Approaches for Smart Grid Integration and Optimization, Energy Convers. Manag. X. (2024) 100724. https://doi.org/https://doi.org/10.1016/j.ecmx.2024.100724.

[120] S. Chen, G. Heilscher, Integration of distributed PV into smart grids: A comprehensive analysis for Germany, Energy Strateg. Rev. 55 (2024) 101525. https://doi.org/https://doi.org/10.1016/j.esr.2024.101525.