energies

Perspective

Energies and Its Worldwide Research

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Abstract: Energy efficiency and management is certainly one of the key drivers of human progress. Thus, the trends in the energy research are a topic of interest for the scientific community. The aim of this study is to highlight global research trends in this field through the analysis of a scientific journal indexed exclusively in the energy and fuels category. For this purpose, a journal has been selected that is in the center of the category considering its impact factor, which is only indexed in this category and of open access, Energies of the publisher MDPI. Therefore, a bibliometric analysis of all the contents of the journal between 2008 and 2020, 13,740 documents published, has been carried out. Analyzing the articles that are linked to each other by their citations, 14 clusters or research topics have been detected: smart grids; climate change–electric energy community; energy storage; bioenergy sources; prediction algorithms applied to power; optimization of the grid link for renewable energy; wind power; sustainability of power systems; hydrocarbon improvements; conversion of thermal/electrical energy; electric motor advancements; marine renewable energy; hydropower and energy storage; and preventive techniques in power transformers. The main keywords found were electric vehicle, renewable energy, microgrid, smart grid, and energy efficiency. In short, energy research remains necessary to meet the future challenge of sustainable energy with high efficiency and the exploration of new renewable resources, all for increasingly sustainable cities.

Keywords: renewable energy; electric vehicle; microgrid; smart grid; energy efficiency; optimization

1. Introduction

Energy generation requires capital investment for the construction and maintenance of power facilities. To an extent, all countries in the world need to generate their energy either from renewable sources with what they have on their territories, or by importing the energy they need and can afford. Energy research improves, among other things, sustainable energy generation and energy saving [1].

Renowned scientific journals are indexed in the Journal Citation Rank (JCR), which for experimental science journals is the Science Citation Index Expanded (SCIE) and for social science journals is the Social Science Citation Index (SSCI). The JCR database organizes the journals by scientific categories according to the topics published in the journal. In total, in 2019 there were 234 categories, of which 178 were from the SCIE and the rest from the SSCI.

The energy category is by definition, the category of energy and fuels. Energy and fuels covers resources on the production, use, application, conversion, and management of nonrenewable energy (combustible) fuels (such us wood, coal, petroleum, and gas) and renewable energy sources (solar, wind, biomass, geothermal and hydroelectric). However, resources dealing with nuclear energy and nuclear technology appear in the nuclear science and technology category. The number of journals in this category may change every year, depending on new journals (upon request and at least 3 years of evaluation), withdrawals, or changes of category. In particular, the number of journals in this category has increased from 58 in 1997 to 112 in 2019.

The main objective of this work is to study the scientific evolution in the field of energy, for which the category energy and fuels has been selected. To date, research within this category has been based only on bibliometric studies of particular aspects of it, such as alternative energy research, biomass energy and environment, energy efficiency, low carbon development transformation, solar power, or coal spontaneous combustion.

Therefore, the new approach in this research is to explore the category through a representative journal. By representative journal we mean one that is only indexed in this category, that is positioned at the center of it, and that if possible is open access so that everyone can have access to it.

The energy and fuels category has had the following numbers of journals indexed, over the last 5 years; see Figure 1: 2019 (112), 2018 (103), 2017 (98), 2016 (92), 2015 (88). Energies journal has occupied the following positions during these years: 2019 (66), 2018 (56), 2017 (48), 2016 (45), 2015 (43). Furthermore, it is only indexed in this category and is open access, so it is the perfect journal to carry out this study on.

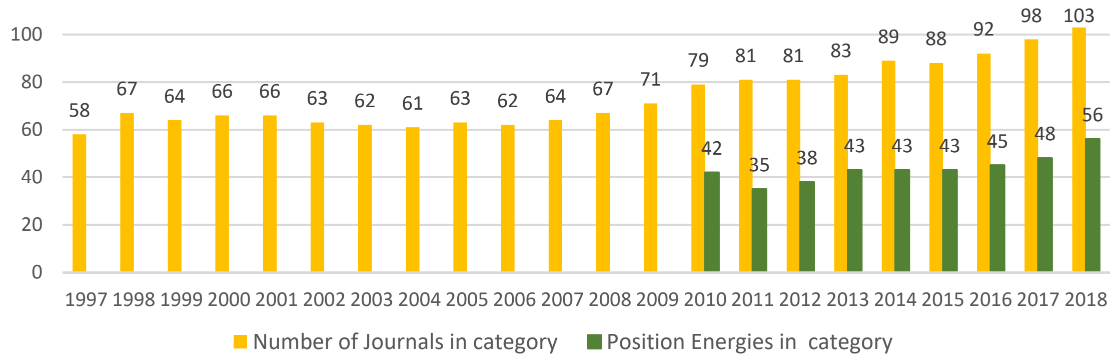


Figure 1. Evolution of the energy and fuels category and its relationship with MDPI's Energies journal.

MDPI's Energies journal brings together the most relevant contributions in different areas related to energy management. The smart grid topic is an example where information technology developments applied to the automated and dynamic management of efficient and quality electricity supply are integrated and where research is carried out into improvements in automation along with the incorporation of hybrid energy source systems [2,3]. The algorithms that forecast the operation of the network or predict short or long-term electrical power needs are studied as a subject in themselves [4,5]. The growing concerns of global change with greenhouse effect emissions and the consequently increasing demand for electrical energy production is another topic that has been widely discussed. Most contributions propose renewable energies as an alternative that is more respectful of both issues [6,7]. Due to the merits of bioenergy for environmental sustainability, biofuel technology plays a crucial role in the development of renewable energies [8,9]. The design of high-performance and cost-effective technologies for bioenergy and biochemical production from waste resources in a biorefinery which fully exploit the potential of biomass and waste streams, constitutes some of the challenges in this area [10].

Solutions to resolve deficiencies or difficulties in connection to the network of renewable energy sources has its own theme [11,12], and some renewable energy sources such as wind power [13,14], thermal energy [15,16], bioenergy and marine energy [17,18]. All these considerations are linked to the technological evolution and growth of the renewable energy market. The economic considerations are analyzed with the aim of assessing the viability of renewable energy implementation to guide decisions on the future of energy. The proposals for the storage and generation of green energy valid for electric vehicles (EVs) [19,20] and other applications as backup energy to compensate for the random characteristics of renewable energies [19] are much-discussed topics among the documents published by MDPI's *Energies* journal [21].

Electric motors are widely used within the renewable energies context, and several studies have been published on the design of generators for wind power, wave power, hydropower and electric cars (EVs) [22,23].

Primary equipment in electrical networks, such as power transformers, plays a very important role in distribution networks, where a break can make a power distribution line unserviceable [24]. Insulation condition monitoring is a priority in order to reduce malfunctions and their impacts on the electrical distribution service [25]. Another topic studies techniques and tools for early detection of insulation faults and reductions of their impacts on the distribution network [22].

Oil fields are depleting their reserves and no new fields can be found to meet the demand. This branch is investigating methods, models, and processes for safe and efficient extraction of non-conventional resources to solve the increase in demand for fossil fuel consumption [26,27].

A study of the journal's sections and Special Issues from 2008 to 2020 and their evolution over time was carried out, in which the relationship between the number of citations of articles and Special Issues can be observed. This has led to the journal evolving in 12 years to an impact factor in 2019 of 2702 (Q3). Subsequently, an analysis was done of the relationships between the communities involved in providing energy solutions to society. From the analysis, 14 communities with different themes and interests were identified. From the study of the communities, the perspectives for future work were defined, mainly in improvements in energy efficiency and sustainable solutions.

2. Methodology

There are many search engines on the web based on indicators such as number and quality of contributions according to the metrics of the journal or the author. However, these searches do not quantify the collaborations established between authors. These collaborations establish multidisciplinary thematic communities of collaboration. Progress in science and engineering is largely established through collaborations in the short or long term. Collaborations are not only established between authors. Sometimes public or private research entities, with or without profit motives, favor them. It is important to promote metrics that incorporate author relationships. Scopus is one of the largest scientific databases with worldwide bibliographic management and of recognized relevance in document searches. In this work, Scopus was used as a search engine and its API (Application Programming Interfaces). It was applied successfully in other works [28] to extract the information and provide the relationships between author and papers. Using the API and following the methodology applied in [29], a restricted search has been carried out on MDPI's *Energies* journal (ISSN 1996-1073), selecting the first 11 years and all the documents published in the journal in order to find the global relationships between the communities generated, their authors, and their research institutions. This required a process of debugging to avoid unnecessary information that would have prevented an overview. It also reduced the number of documents and spurious relationships. In the purging process, documents that had no relationships within the generated communities were removed. This data were finally analyzed using statistical tools based on diagrams and presentations of the data processed. The open-source tool Gephi was used, which incorporates statistical resources and data visualization.

3. Results and Discussion

3.1. General Findings

MDPI's *Energies* journal is included in the energy and fuels category. This category covers resources for the development, production, use, application, conversion, and management of non-renewable fuels such as wood, coal, oil, and gas, and renewable energy sources such as solar, wind, biomass, geothermal, and hydroelectric. Within this last category, it does not cover nuclear energy or technology (nuclear science and technology category). Figure 1 shows the evolution of energy and fuels from its beginnings in 1997, with 58 journals, to the 103 journals registered in 2018. The figure shows the position of MDPI's *Energies* journal in relation to the category, being predominantly in the second quartile and spending only 2 years (2013 and 2018) in the third quartile. Data on the number of published articles in the energy and fuels category were not available until 2003. From 2003 (5928 articles, 2% of the total recorded) to 2018 (39,585 articles, 13% of the total recorded) 302,650 articles have been published, a gradual increase of 11% over the first recorded value (Figure 2). The number of citations has followed a similar relationship to the number of articles to more published documents. The evolution goes from 56,509 citations in 2003 (1% of the total recorded) to 1,540,158 citations in 2018 (7,564,902 total citations), where the highest annual increase in percentage occurred (from 2015 with 11% to 2018 with 20% of the total recorded). If we relate the amount of articles/number of citations, we obtain a decreasing evolution; at first there is a ratio of 0.1 until reaching 0.03 in 2018.

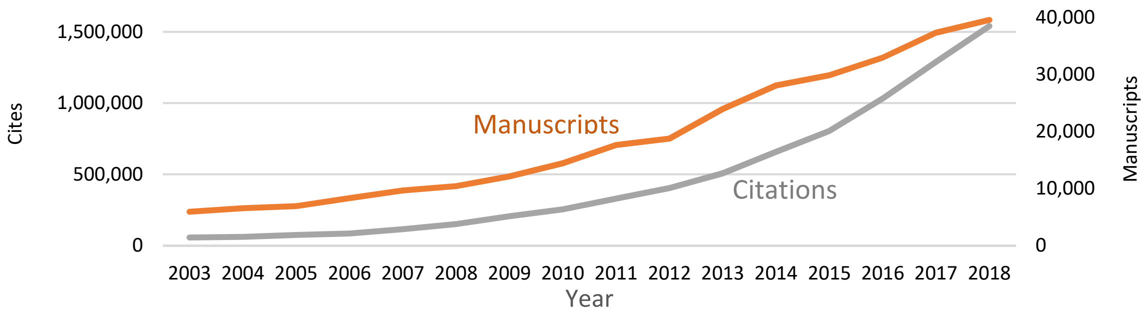


Figure 2. Evolution of citations and articles in the category energy and fuels.

MDPI's *Energies* journal was founded in 2008, and two years later it was indexed in the Science Citation Index Expanded (SCIE) in the third quartile. Figure 3 shows the most significant milestones since its foundation and their relations to the number of articles published. One year later, in 2011, it reached the second quartile where it remained until 2013; then it fell to the third quartile. In 2014 it reached the second quartile again and remained there until 2017, where the journal was divided into five topical sections: Electrical Power and Energy System, Energy Fundamentals and Conversion, Energy Sources, Energy Storage and Application and Sustainable Energy. In 2018 the journal was placed in the third quartile and added two new sections: Thermal Management and Energy Economics and Policy. In 2019 a total of eleven new sections were established: Hydrogen Energy; Energy and Buildings; Geo-Energy; Energy and Environment; Bio-Energy; Solar Energy and Photovoltaic Systems; Wind, Wave and Tidal Energy; Smart Grids and Microgrids; Advanced Energy Materials; Electric Vehicles; State-of-the-Art Energy Related Technologies.

MDPI's *Energies* journal is a journal that promotes publication in nine thematic areas, as shown in Table 1. Each thematic area includes different topics, except in Exergy and Energy Research and Development sections. Based on the subject areas, the journal has developed 20 sections with 931 Special Issues between 2020–2021 and 7416 documents published until April 2020. Figure 4 shows the distribution by percentage of articles according to sections. The five sections with the most publications are the most generic, such as Electrical Power and Energy System with 2080 documents (28.05%), Sustainable Energy with 746 documents published (10.06%), Energy and Environment with 456 documents (6.15%), Energy Sources with 414 documents (5.58%), and Smart Grids and Microgrids with 408 documents (5.50%). The remaining sections have less than 401 documents published. Figure 5 shows the distribution of Special Issues according to section. The Electrical Power and Energy System section is the one with the highest number of documents published and the highest number of Special Issues with 12.57% and 117 Special Issues. The rest do not have a direct relationship between sections or the number of documents published. The Special Issues are distributed in the more specific sections, such as Smart Grids and Microgrids (10.42%), Energy Economics and Policy (7.52%), Energy and Buildings (6.44%), and Electric Vehicles (6.44%).

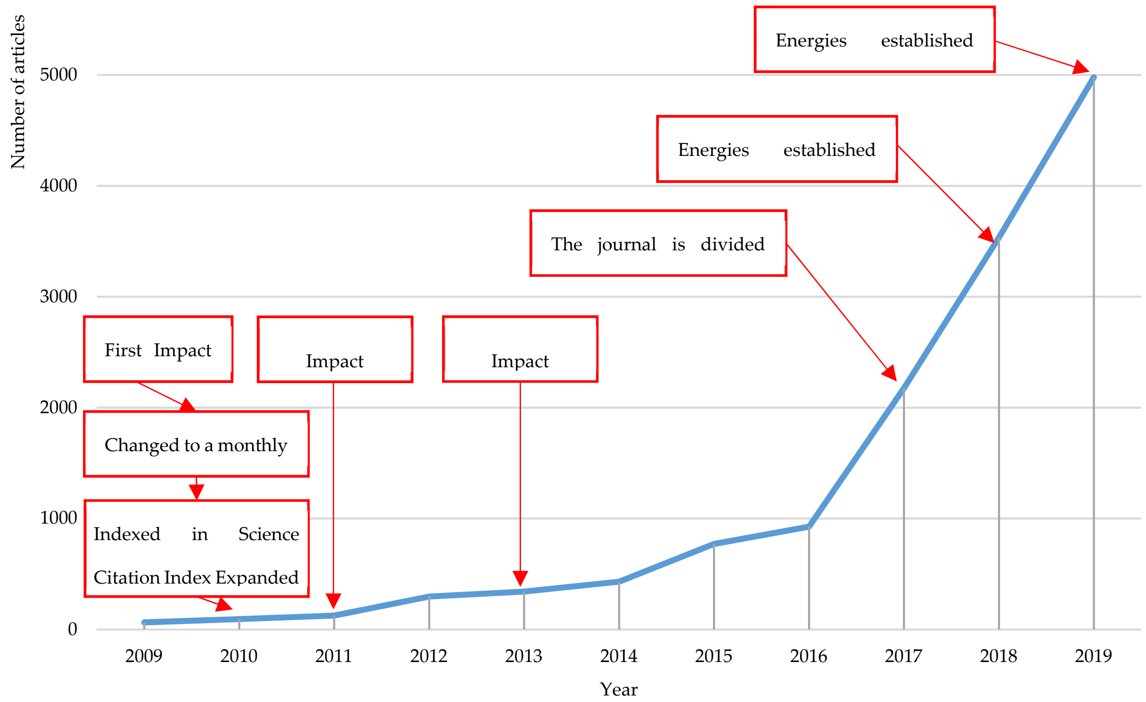


Figure 3. Evolution of number of publications in MDPI's *Energies* journal.

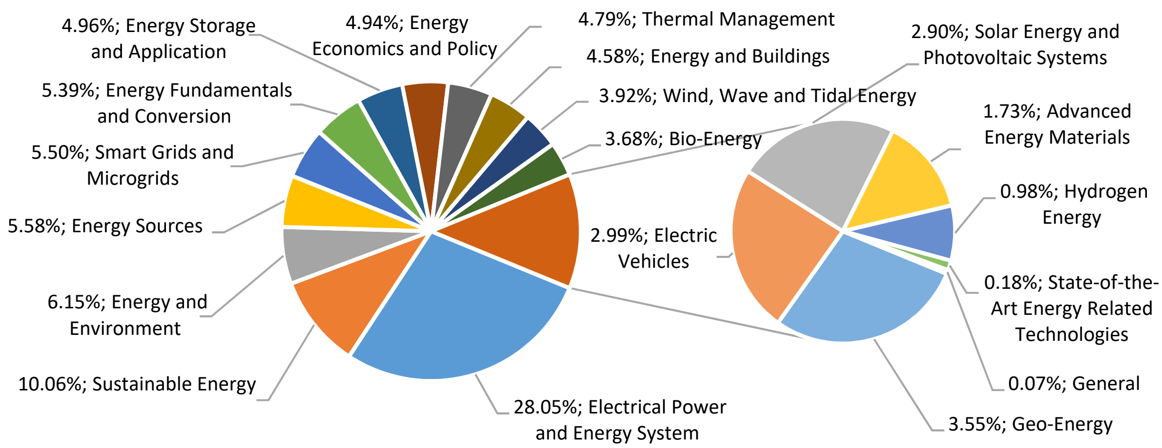


Figure 4. Distribution of manuscripts by section.

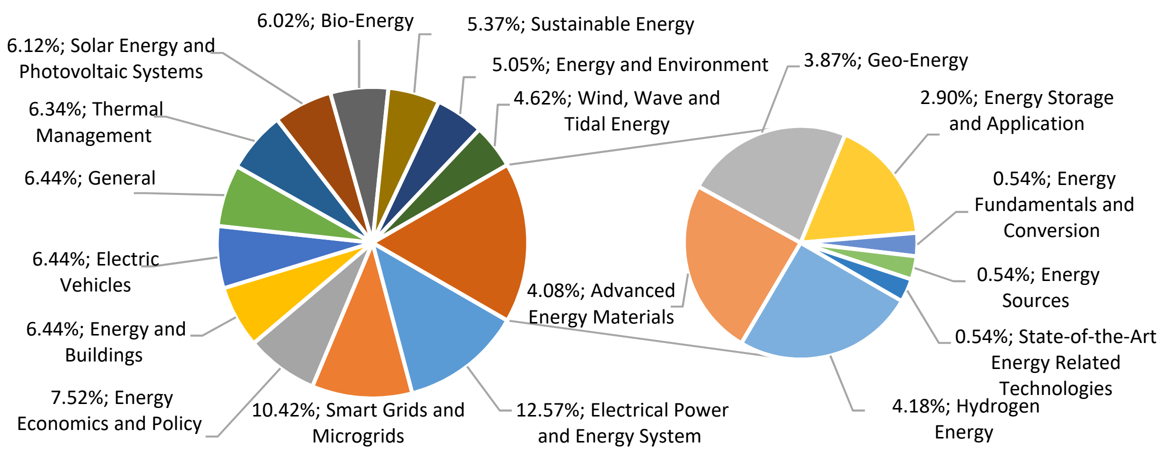


Figure 5. Distribution of Special Issues by section.

Table 1. Subject Areas in journal MDPI *Energies* journal.

Subject Areas	Topics	Subject Areas	Topics
Energy Fundamentals	Thermodynamics Energy forms Heat Energy transformation Mechanical energy Blue energy Internal energy Energy quality Energy density Energy flow	Energy Conversion Systems	Combustion: Conventional and Advanced Thermal Engines Boilers Heat Exchangers Electric-, Hybrid- and Hydrogen Vehicles Alternative Energy Vehicles Electricity Generation Power Plants Co- and Trigeneration Energy Cascading Domestic and Industrial Applications Aeronautical and Aerospace Energy Systems
Primary Energy Sources	Fossil: Coal, Gas, Nuclear, Oil Renewable: Geothermal, Hydraulic, Ocean, Solar Thermal, Solar Photovoltaic, Solar High-T, Wind	Energy Policy	Energy Saving and Efficiency Energy conversion and management Environmental Effects Energy and Environmental Indicators Sustainable Energy Systems "Green" energy
Secondary Energy Sources and Energy Carriers	Biomass and Biofuels Hydrogen Liquified Natural Gas Microwave Energy conversion Waste-derived fuels	Exergy	No topics
Energy Exploration and Exploitation Intermediate and Final Energy Use	Energetic materials Energy storage Power supply Distributed generation Energy and Buildings Power Transmission Energy Infrastructure	Energetics	Bioenergetics Chemical Energetics Energy in Physical Cosmology
		Energy Research and Development	No topics

Figure 6 shows the relationship between published documents and the number of citations received. Both the documents and the citations maintain an exponential distribution over the years. There is also a relationship (citations/published documents) that the greater the number of published documents the greater the number of citations; the relationship between the two is not uniform, going from approximately 1 in 2010 to an increase of 4.69 in 2014. After that year, the tendency is to decrease until it reaches 3.07 in 2017, and again, there is an increase until the relationship reaches 4.3 in 2019. This increase may be the result of a good policy on Special Issues focused on very specific topics and looking for publishers who specialize in them.

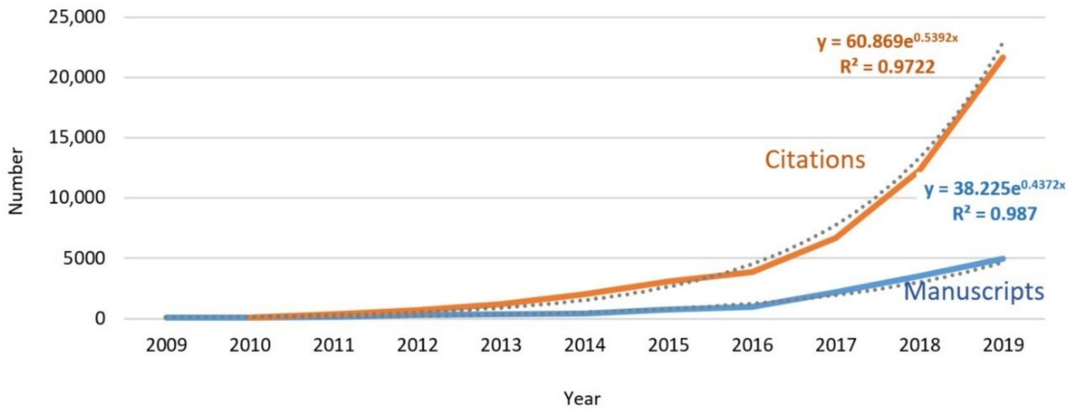


Figure 6. Distribution of published documents and citations by year.

3.2. Establishing Communities

In this work, a general search was conducted, wherein 13,740 documents up to 2020 have been obtained. In Figure 7, they are represented along with their relationships. A filtering process was performed to discard documents not linked to the core relationship set (unlinked articles in Figure 7). Only 9865 documents were found (core of Figure 7) to be strongly linked—this means manuscripts that are cited or cite other manuscripts of the journal. The results imply a final total of 19,835 relations. Figure 7 shows the distribution of the 14 communities detected after the filtering process with Gephi. Although there are several communities with well differentiated concentrations, the majority show strong interactions with various themes.

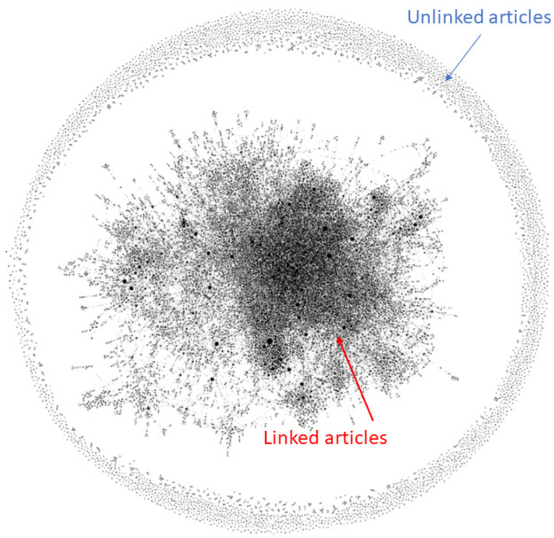


Figure 7. Manuscripts published in MDPI's *Energies* journal.

In Figure 8 the articles are represented as nodes. Each node is a published document, and the size of the node is a function of its relationships with other articles. The larger the size shown, the greater the influence of the author within the community. Not only were the common search engine metrics considered, but the collaborations between the authors were as well. This is the reason why an author who has a published and highly referenced document but who works alone will have a smaller sized node than one less referenced but with more collaborations. This figure shows the distribution of the 14 communities or clusters detected that publish on the topics included in MDPI's *Energies* journal with the Gephi tool.

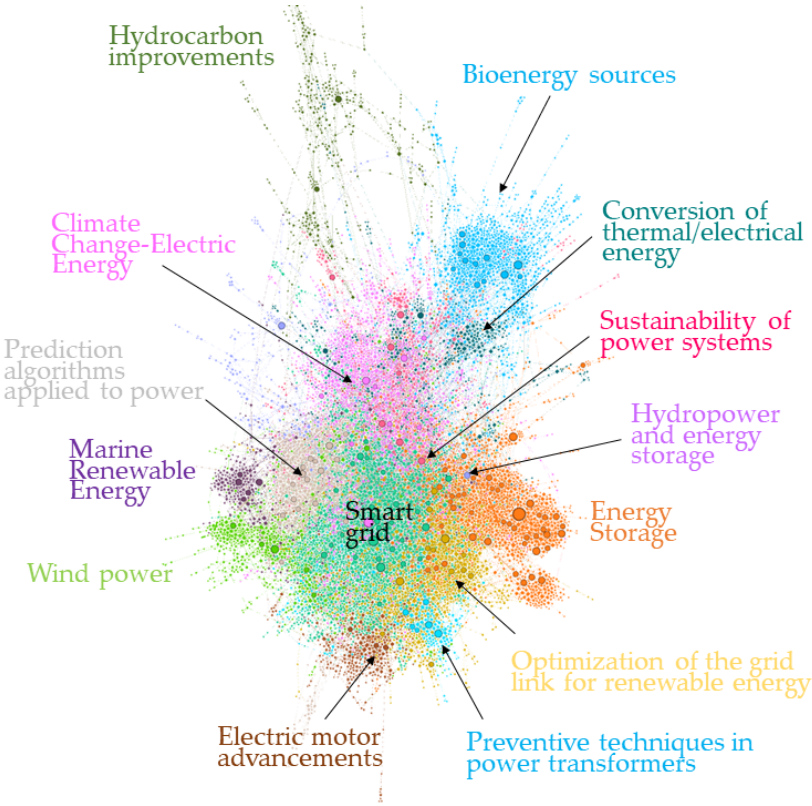


Figure 8. Scientific communities or clusters of manuscripts.

Figure 9 presents the contribution of each community as a percentage. Due to the interrelationships in Figure 8, it is difficult to see the total size of each community. There are four communities with contributions of more than 10%, including smart grids with 16.74%, which is the largest (advances in the application of communications technology to electrical networks), followed by climate change–electric energy with 12.62% (renewable sources as an option for reducing the effects of climate change and the greenhouse effect), followed by energy storage with 12.24% (advances in ecological storage sources. and their uses are evaluated according to application), and bioenergy sources with 10.51% (evaluates innovations in alternative biological-based sources).

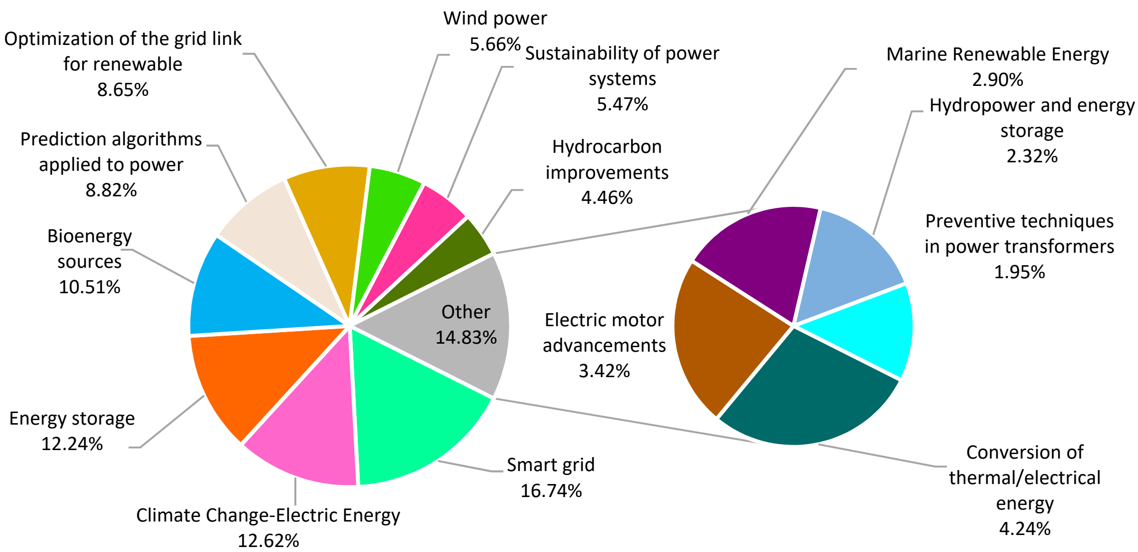


Figure 9. Representation of the distribution of the percentages of communities within *Energies*.

The keywords obtained from the documents were analyzed. A total of 50,978 keywords have been obtained, a minority of which are acronyms. For the study, the acronyms were replaced by their equivalent words, the hyphens were eliminated, and all the words were capitalized. The words in the singular were considered and the plurals added. As a result, 25,468 different words were obtained, 49.95% of the initial 50,978 keywords. Figure 10 shows the most widely used keywords globally. Figure 11 shows the 20 most repeated keywords globally, and they are coded according to color regarding the community that contributes most to each keyword. Most of the keywords in the top 20 include the eight largest communities, which is reasonable considering that the remaining six contribute to 19.30% of the studied documents. Some of the words represented correspond to community names, such as smart grid, energy storage, and wind power. Electric vehicle, with 0.60%, is the most used keyword with 308 repetitions, and with contributions from 11 of the 14 communities studied, it is one of the most common focuses by various communities from different perspectives, such as energy storage, climate change, electric energy, and electric motor advancements. Renewable energy is the most cross-cutting issue for most communities with 0.53% and 272 repetitions, followed by microgrid and smart grid with 0.46 and 0.44%, and both are closely related to the smart grid community. The rest of the words range from 0.38 to 0.19%. There are 221 keywords with contributions equal to or greater than 20 repetitions (0.86%), and the most striking thing is that 19,647 words have only been used once (38.55% of the total) which is not representative of the visibility of the documents in searches.

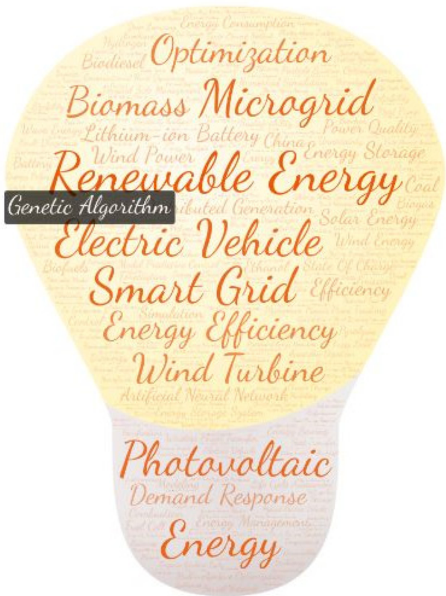


Figure 10. Representation of the most globally representative keywords.

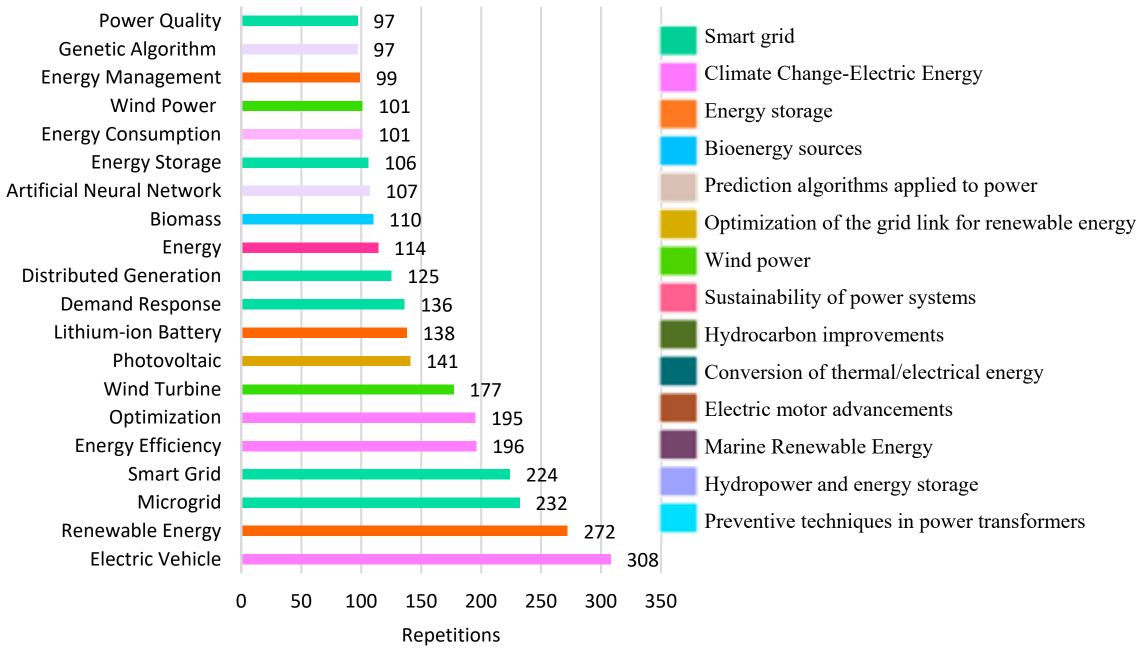


Figure 11. Distribution of keywords and the representation of the communities with the greatest contributions to the globally most representative words.

3.3. *Analysis of Communities*

Each community is closely interlinked with the rest. The main nodes of each community and their most significant contributions were analyzed. This should allow an understanding of the scope of the research and its relationships outside the community.

3.3.1. Smart Grid Community

The diversification of energy sources incorporated into electricity supply networks makes the concept of the energy grid obsolete. The current networks are complex and each include a varied collection provided by different sources. Some of them are random in time, such as renewables, which requires automated management systems to offer an efficient, sustainable, economic, and safe service. These networks incorporate hardware and software systems to automate the electricity supply network. These networks are known as smart grids; they integrate information technology developments (algorithms and tools) applied to the automated and dynamic management of the efficient and quality electricity supply. This community studies how to improve smart grids in hybrid energy source systems.

This community is made up of 1251 documents. It is the largest community with a contribution of 16.74% to published documents. Figure 12a shows the concentration of the nodes, where there are many medium-sized nodes. The three most outstanding nodes include a widely cited research article [30], a review with few but very related citations [31], and a summary of a Special Issue that has no citations, although its author does have strong collaborative links [32]. The three nodes are:

- "Improvement of transient stability in a hybrid power multisystem using a designed NIDC (Novel Intelligent Damping Controller)" with 76 citations [30].
- "A comprehensive review of operation and control, maintenance and lifespan management, grid planning and design, and metering in smart grids" with three citations [31].
- "Special Issue *Intelligent control in energy systems*" without citations [32].

Figure 12b shows the top 10 keywords with a representation of 8.00% of those used out of a total of 8593 keywords used in this community. All of the words shown have direct relationships with both small and large-scale intelligent distribution networks. The words microgrid (1.59% of the total words in this community), smart grid (1.41%), power quality (0.51%), and optimization (0.49%) are global words represented in the top 20. The words power quality and optimization are used in several communities, as they are some of the innovation objectives of many of the energy advances and are applied by optimizing grid or conversion system features to improve effectiveness and efficiency.

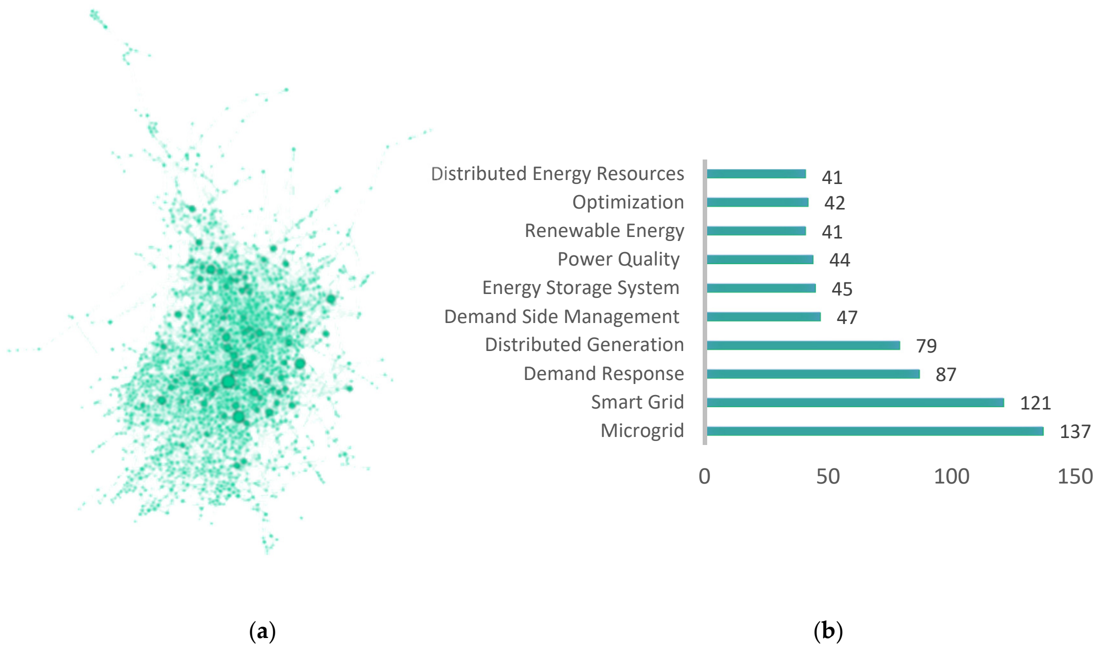


Figure 12. Smart grid: (**a**) manuscripts published, (**b**) keywords.

Smart grids incorporate real time measurements throughout the electrical system and must address different challenges, such as disturbances, voltage regulation, implementation of smart meters (SM) through advanced measurement (AMI), quality supply service, consumer awareness by applying hourly incentives to the cost of energy, distributed generation incorporating small sources of renewables in stations as close as possible to consumers, and microgrids with maximization of available resources, intelligent building.

Smart grids incorporate intelligent electronic devices (IED) to operate efficiently and effectively. These devices can be improved and there are currently a large number of publications that incorporate these improvements as challenges for this community. In [31] they reviewed smart grids in order to incorporate technological advances (software, hardware, and new materials). They classified the research areas of this subject into four sections: efficient operation and control, maintenance and lifetime management, planning and grid design of the new networks, and advanced measurement.

Hybrid systems require equipment and network management to reduce power fluctuations, voltage drops, etc., in order to provide reliable and efficient service. In [30] they applied a linear proportional-integral-derivative (PID) controller, a critical adaptive network, and a diffuse functional link-based recurrent neural network (FLNRFNN) for application in intelligent damping (NIDC) as a static synchronous compensator (STATCOM). The controller is designed to reduce power fluctuations in a multipower hybrid system. In this study, a hybrid system composed of an offshore wind farm (OWF) and an offshore wave power park (SWPF) was used. The system consisted of a battery energy storage system (BESS) and a micro-turbine generation (MTG). The results show that the controller is capable of improving the damping and stabilization of the network in unstable conditions.

Demand-side management is mainly implemented for industrial consumers, leaving aside residential systems. Adnan Ahmad et al. (2017) proposed an optimized intelligent household energy management system (OHEMS) using heuristic algorithms [33]. This system facilitates the integration of renewable energy (RES) and the energy storage system (ESS) into demand-side management (DSM) activities. Among the objectives of the management system is to minimize the electricity bill by scheduling household appliances and energy storage according to the value of the market price of electricity. The application of the simulated system manages to reduce the bill by 40.05% in cost and 41.07% in peak to average ratio compared to the unscheduled load. In addition, reducing the peak to average ratio improves the stability and reliability of the electricity system.

With the incorporation of electricity supplies based on renewables, which present a great deal of fluctuation in the power delivered, research has been carried out on techniques and storage systems with the aim of providing a stable and sustainable service. This has led to a great deal of time and effort being invested in improving and cheapening the systems so that they can compete commercially with the old, non-ecological storage systems. Reference [34] it presents a review of storage systems with the aim of providing guidance on selecting the best battery technology options for each application.

The challenge of incorporating heterogeneous entities (energy sources, energy storage, microgrids, distribution networks, buildings, electric vehicles, etc.) in distribution systems makes it necessary to incorporate intelligent control (IC) in the dynamic management of the network. In [32] is a summary of 27 contributions to the Special Issue "Intelligent control in energy systems," which includes innovative designs applied to intelligent control in energy systems.

3.3.2. Climate Change–Electric Energy Community

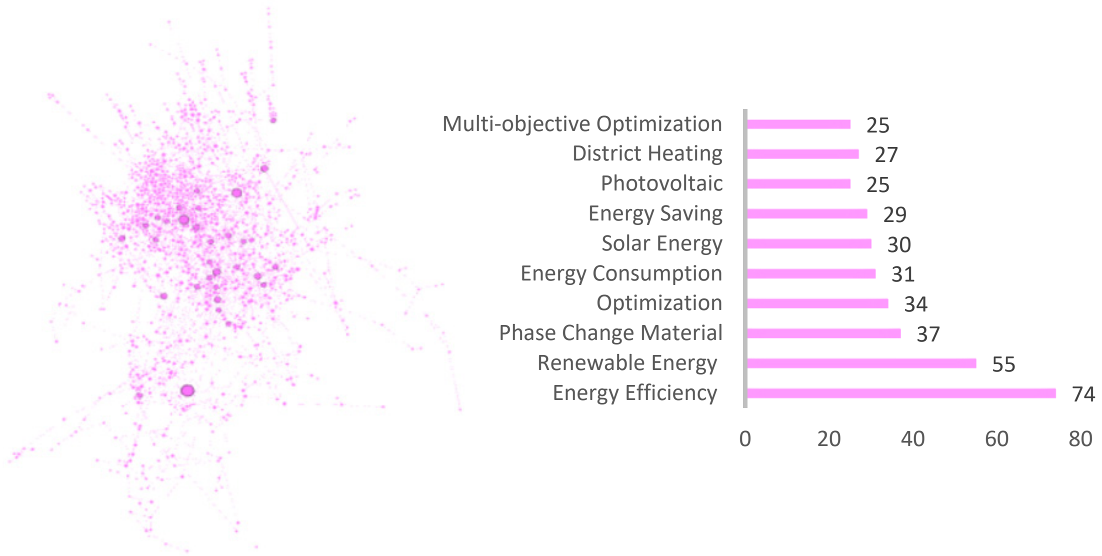
The documents of this community deal with the growing concerns of global change with the greenhouse effect emissions and the increasing demand of electric energy production. The most respectful alternative to both issues is using renewable energies. This community is made up of 1245 documents and is the second largest community, represented by 12.62% of the documents published (Figure 13a), of which the following documents stand out due to their links:

- "Optimization methods applied to power systems" [35].
- "Energy policy and climate change: A multidisciplinary approach to a global problem" [36].
- "Toward an efficient and sustainable use of energy in industries and cities" [37].

The first and second nodes [35,36] are editorial articles from a Special Issue and the third node [37] is a summary of a conference, hence no or few quotations, but many relationships all.

The top 10 keywords in this community contribute 5.6% of the total 6562 words in the community; see Figure 13b. This community seeks to improve the supply of electricity in an environmentally friendly manner; hence one of the most widely used terms is renewable energy with 0.84% of the keywords used in this community, as the community seeks to increase the use of these technologies to minimize the use of other non-environmental technologies. However, for the system to change and for companies to favor ESTs it is necessary that they can also compete cost-wise, and in order to achieve this, optimization (0.52%) and efficiency (1.13%) are essential.

The three main nodes correspond to Special Issues of MDPI's *Energies* journal. Throughout history, different electricity generation policies have been adopted which, in the long term, have not been totally beneficial. This is the case for nuclear power plants, where the pollution caused had not been given due consideration. The threat of climate change has led to a change in seeing electricity production with a more sustainable and ecological vision by reducing polluting emissions into the environment. Vincenzo Dovì and Antonella Battaglini (2015) directed a Special Issue of energy policy which includes prevention of climate change, disruption of food supply chains, the onset of global water stress, and the collapse of political institutions [36]. In continuity with the energy policy and energy efficiency in urban areas and sustainable development, the 12th Conference on Sustainable Development of Energy, Water and Environmental Systems (2017, Dubrovnik, Croatia), the 12th SDEWES Conference and the 13th Conference on Sustainable Development of Energy, Water and Environmental Systems (2018, Palermo, Italy), and the 13th SDEWES Conference were held, where the contributions of scientists to these issues with multidisciplinary involvement were presented. In [38] the most significant contributions to energy policy and energy efficiency in intelligent energy systems, poly-generation and district heating, advanced combustion techniques and fuels, biomass, and building efficiency from the 12th SDEWES Conference were summarized. In [37] a summary is given of the topics discussed at the 13th SDEWES Conference and of interest to readers of MDPI's *Energies* journal, such as the promotion of sustainable energy in different sectors: industries, metropolitan and urban areas, waste heat recovery, waste materials, the water-energy nexus, etc.



(**a**) (**b**)

Figure 13. Climate change–electric energy: (**a**) manuscripts published, (**b**) keywords.

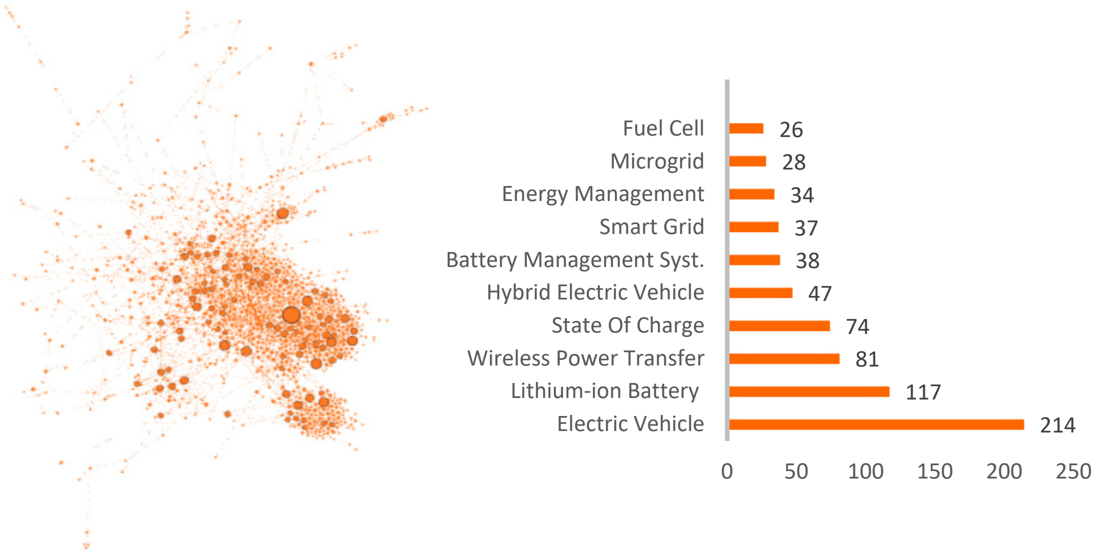
With the increase in distributed generation where conventional and renewable sources are involved, optimization tools are needed to solve the problems associated with large distribution networks, including load flow, fault location, contingency analysis, system restoration after blackout, distributed generation island detection, etc. Reference [35] presents a Special Issue that includes different optimization methods applied to any field of electrical energy. Other than these problems associated with the distribution network, there are those associated with generation, such as integrated renewable energy systems, which are combined cooling, heating, and power systems (CCHP) using renewable energy, where the aim is to minimize the total annual cost (ATC), the emission of carbon dioxide (CDE), and the probability of loss of energy supply (LESP), among others. In [39] a multiobjective optimization model was implemented using an evolutionary algorithm that responds to the reliability and cost objectives of the system. For this purpose, they developed a multiobjective evolutionary algorithm inspired by scenario dominance (s-NSGA-II) whose results have better economic implication under multiple scenarios with a hybrid renewable energy system.

3.3.3. Energy Storage Community

Researchers are studying different proposals for storage and generation of green energy for electric vehicles (EVs) and other applications. The choice of the battery for the EV must be emission-free (zero emissions), not use polluting elements, have a high capacity (ampere-hours, Ah), high stored energy (Watt-hours, Wh), a usable state of charge, high life cycle, maximum discharge current capacity, etc. The most common batteries are those based on nickel as a nickel–metal hydride (Ni–MH). They are environmentally friendly, but their life cycles are short, and they pose problems of high self-discharge rate. This community consists of 1207 documents. It is the third-largest community with a contribution of 12.24% of published documents. Figure 14a shows that there is a main node for its size [20]; this node gathers a very large number of citations with 453 citations and many relationships, which indicates that one of the authors is responsible for a research group that collaborates with many others and that the subject matter is very important for this community. Other smaller nodes stand out. The three nodes that stand out most for their relationships are:

- "Evaluation of lithium-ion battery equivalent circuit models for state of charge estimation by an experimental approach" with 453 citations [21].
- "Bridging the gap between automated manufacturing of fuel cell components and robotic assembly of fuel cell stacks" without citations [40].
- "Towards a smarter battery management system for electric vehicle applications: A critical review of lithium-ion battery state of charge estimation" with 15 citations [41].

Figure 14b shows the top 10 keywords of this community—6095 different keywords. The ten most representative keywords account for 11.42% of those used in this community. Among the most representative keywords are the ones related to the EV with 3.51% and hybrid electric vehicle (0.77%), and those related to the smart grid distribution (0.61%) and microgrid (0.46%); and the rest include lithium-ion battery (1.92%), wireless power transfer (1.33%), state of charge (1.21%), battery management system (0.62%), energy management (0.56%), and fuel cell (0.43%). Lithium and fuel cell batteries are the most studied storage technologies recently driven by the need to lower EV battery costs to make them competitive.



(**a**) (**b**)

Figure 14. Energy storage: (**a**) manuscripts published, (**b**) keywords.

The lithium battery has great advantages, such as light weight, high energy and specific power, and high energy density. The main disadvantage of lithium batteries is the high production cost compared to Ni–MH. Currently, work is continuing on other lithium combinations, including lithium–sulfur, lithium–iron phosphate, etc. Modelling of battery performance is essential to establishing EV power distribution and control strategies, and estimation of battery state of charge (SoC) and health status (SoH) [42]. The modelling must include the process of charge/discharge of the batteries, considering that it is a non-linear system and highly variable in time. In [21] they propose an improved equivalent circuit model by Thevenin, a double polarization (DP) model for lithium-ion batteries in electric vehicles. The DP model adds an additional RC (resistance-condenser) to simulate electrochemical polarization and concentration polarization separately. The authors use a genetic algorithm to identify the parameters where SoC is convergent within an acceptable error margin.

Estimating the state of charge of the battery is complex, so different intelligent battery management strategies (BMSs) are implemented to measure SoC accuracy and ensure a longer battery life. In [41,43] they propose the main characteristics of a BMS and review the methods of SOC estimation that must solve the effects of ageing, temperature, sensor drift, and external disturbances to maintain the safety and reliability of the battery.

The scientific community continues to work on finding low-cost mass storage systems. Advanced manufacturing research and development are needed to produce high volume, low cost fuel cell power plants. The proton exchange membrane fuel cell (PEMFC) has the advantages of delivering higher gravimetric and volumetric power density and operating at lower temperatures, with fast start-up time and less wear on system components In [40] a robot (double-arm robot with artificial vision) is proposed for automated manufacturing for the assembly of fuel cell components. The proposed system identifies asymmetric fuel cells and reorients them for robotic assembly.

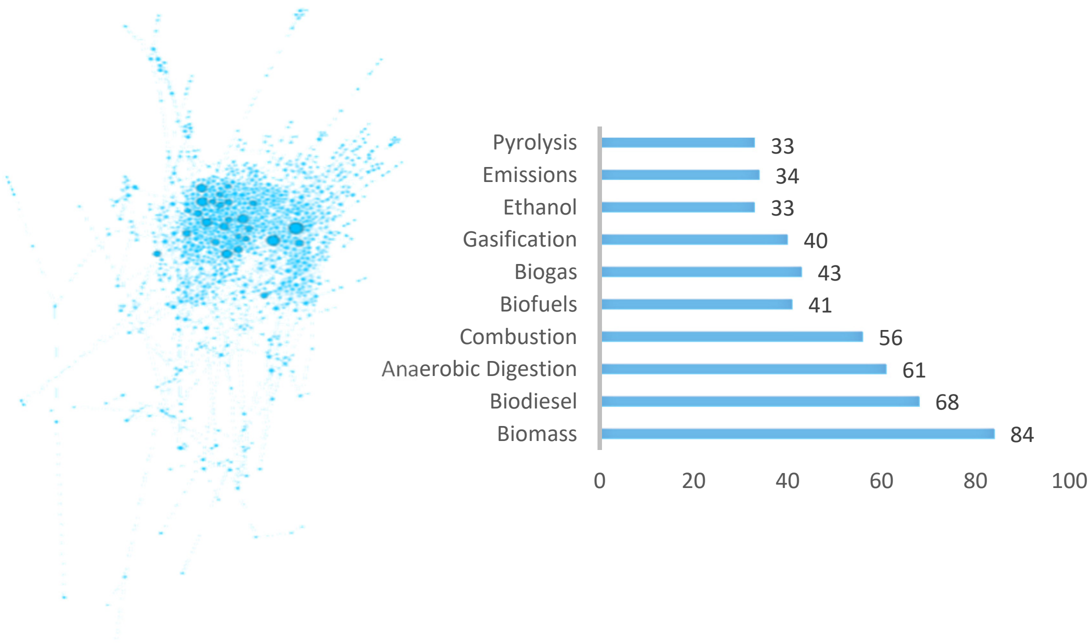
3.3.4. Bioenergy Sources Community

Bioenergy a renewable energy source that is mainly used to replace fossil fuels in order to reduce greenhouse gas emissions. Biofuels for bioenergy include charcoal, biochar, biodiesel, bioethanol, biobutanol, pyrolysis and liquefaction oils, synthesis gas (syngas), biogas and biohydrogen, etc. Due to the merits of bioenergy for environmental sustainability, biofuel technology and biofuels play a crucial role in the development of renewable energies. In this context, the evaluation of the environmental, technological, economic, and social sustainability of the concepts developed is of extreme importance. The design difficulties of high-performance and cost-effective technologies to produce bioenergy and biochemicals from waste resources with the biorefinery concept, which fully exploits the potential of biomass and waste streams, are part of the challenges of this community.

This community consists of 1037 documents. It is the fourth community with a contribution of 10.51% of published documents. Figure 15a shows a larger node [44] which corresponds to a review and two slightly smaller ones—one is an editorial article from a Special Issue [45] and another is a research article [46]—then there are several medium sized ones and many already small ones. The three nodes that stand out most are:

- "Review on the use of diesel-biodiesel-alcohol blends in compression ignition engines" with 11 citations [44].
- "Biofuel and bioenergy technology" with one citation [45].
- "Biomass chars: The effects of pyrolysis conditions on their morphology, structure, chemical properties and reactivity" with 41 citations [46].

This community has used 5504 different keywords. Figure 15b shows the top 10 bioenergy sources keywords, which constitute 8.96% of the total number of keywords used by this community. The majority are bioenergy sources, such as biomass (1.53%), biodiesel (1.24%), biogas (0.78%), and biofuels (0.74%), and the rest are processes or products of bioenergy conversion.



(**a**) (**b**)

Figure 15. Bioenergy sources: (**a**) manuscripts published, (**b**) keywords.

Governments are encouraging scientists and businesses to change their strategies from a fossil fuel-based economy to a resource-based economy because of economic and environmental issues related to the inevitable depletion of fossil fuels. There are various processes which allow biomass to be transformed into energy products for use, including biorefineries, processing of biomasses to produce heat and electricity, pyrolysis of biomasses, etc. In [46] they studied solid coal as a product of biomass pyrolysis. Biofuels are some of the alternative fuels with the function of reducing harmful gas emissions. Biofuel mixtures with fossil fuels are used for internal combustion engines (IC). In [44] the authors present a review of biofuel production and its effects on internal combustion engines (combustion, efficiency, and emissions) and the application of biofuel blending. The synthesis of biofuels from synthetic gas is a viable and effective way of addressing global energy needs. Reference [10] presents a review of the predominant technologies for biomass gasification and biofuels from synthesis gas by biomass gasification.

MDPI's *Energies* journal has a Special Issue "Bioenergy and biochemicals production from biomass and residual resources" applied to promote cost-effective and technologically sound solutions for the next generation of bioenergy and biochemical production systems. In [47] 21 contributions of the Special Issue are presented. In 2019 the Special Issue "Biofuel and bioenergy technology" was published to promote progress in the substitution of fossil fuels and combustion free of harmful emissions. In [45] 27 contributions to the Special Issue are reviewed.

3.3.5. Prediction Algorithms Applied to the Power Community

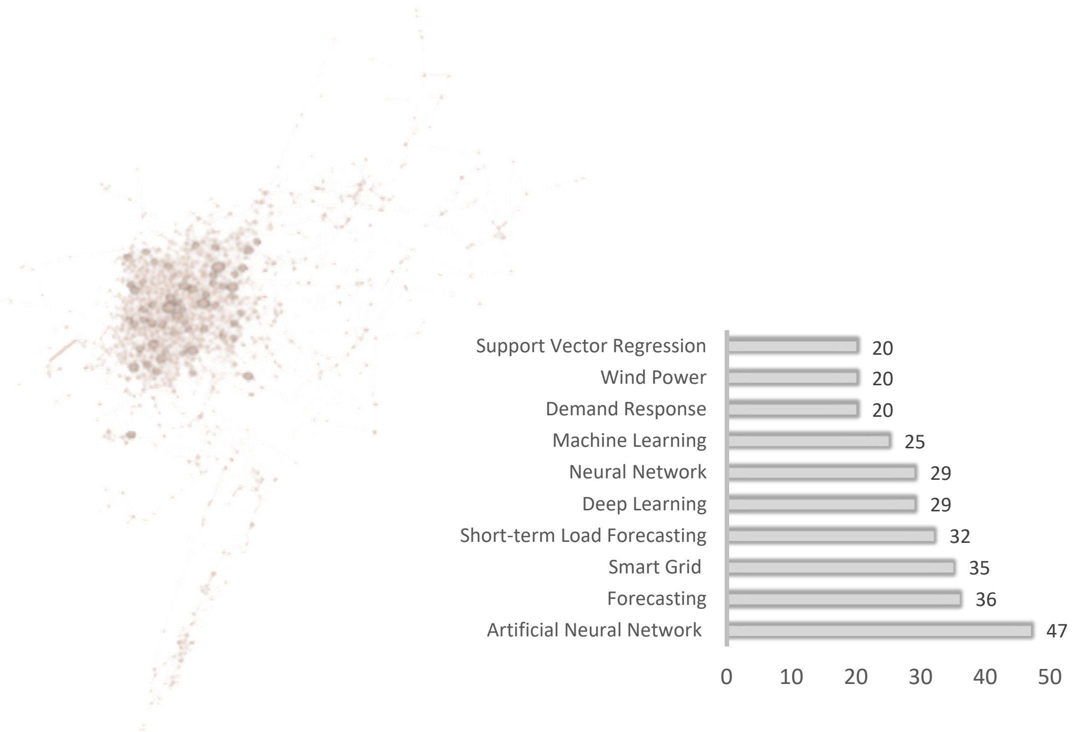
This community is dedicated to algorithms that forecast the operation of a network or predict electrical power needs in the short or long term. It is made up of 870 documents, with 8.82% of the documents published, and is the fifth largest community. Figure 16a shows that this community has three principal nodes, which are differentiated from the rest, and just over twenty medium sized ones. The three main nodes are:

- "Short-term solar irradiance forecasting model based on artificial neural network using statistical feature parameters" with 170 citations [48].

- "Short-Term Load Forecasting Using EMD-LSTM neural networks with a xgboost algorithm for feature importance evaluation" with 85 citations [49].
- "Deep neural network based demand side short term load forecasting" with 78 citations [50].

The keywords of prediction algorithms applied to the power community are shown in Figure 16b. It also shows the top 10 keywords with a total of 6.63% of the 4422 different keywords of this community and the number of times these words are used within the community. All the words shown in Figure 16b are related to renewable energy (such as wind power (0.45%)), with a grid connection (such as smart grid with 0.79%), and the rest are related to characteristics of the algorithms used in prediction, such as artificial neural network with 1.06%.

For the management of the network, a short-term forecast is required (from one hour to one week), by means which of prediction models' algorithms can be implemented with precision. Prediction is very important for energy security, grid control, market operations, and smart grid management. Load variability makes developing prediction models difficult. The scientific community is continuously developing these models in order to improve accuracy in the short term. There are three different types of short term prediction methods: traditional (mathematical multiple linear regression models, stochastic time series, or exponential smoothing), similar day (SD, selection of historical days with characteristics similar to the predicted days, function of the calculation of the Euclidean rule of factors between the historical and the predicted days, same day of the week and climate similar to the predicted days, etc.), and based on artificial intelligence (AI), such as the support vector machine, fuzzy logistic methods, expert system models, Bayesian neural networks, and the artificial neural networks. The traditional ones do not work well for non-linear responses, which does not make them valid for short-term predictions that have non-linear behavior. Similar day-based methods do not usually have a high prediction accuracy and are dependent on the selection of the inputs that model the system.



(**a**) (**b**)

Figure 16. Prediction algorithms applied to the power community: (**a**) manuscripts published, (**b**) keywords.

The output of photovoltaic plants depends on irradiance. The prediction of the possible power in these grid-connected plants is very important for the management of the grid. The main drawback is its difficulty to predict irradiance in the short term, due to their random and non-linear characteristics and variable climatic conditions. In [48] an artificial neural network (ANN) is proposed for the short-term prediction of irradiance based on statistical characteristic parameters (ANN-SFP).

Huiting Zheng, Jiabin Yuan, and Long Chen (2017) proposed a hybrid algorithm for short-term load prediction. This model combines three methods: selection of similar days, decomposition in empirical mode (EMD), and long-term memory neuronal networks (LSTM). The results of applying long-term memory neuronal networks combined with empirical mode decomposition show good prediction of long-term electric charge. If the selection of similar days is added, the results of this work show good prediction in the short term [49].

In [50] the authors propose a short-term load forecasting (STLF) model for smart grids. This model is based on deep neural networks (DNNs). The results show that DNNs provide accurate and robust predictions compared to other forecasting models compared.

Other researchers use big data mining to model temporary energy consumption. In [51] they developed an intelligent data mining model to analyze energy forecasting behavior and trends. To validate the proposed model, they used data from smart meters of energy consumption. Their results obtained 81.89% energy consumption forecast accuracy in the short-term (per hour), and 75.88%, 79.23%, 74.74%, and 72.81% in the long term—i.e., day, week, month, and season respectively.

Ivan Lorencin and collaborators (2019) used genetic algorithms (GA) to estimate energy production. In this document they were used for application in a combined cycle power plant. The multilayer perception design (MLP) was used and compared with different heuristic algorithms [52].

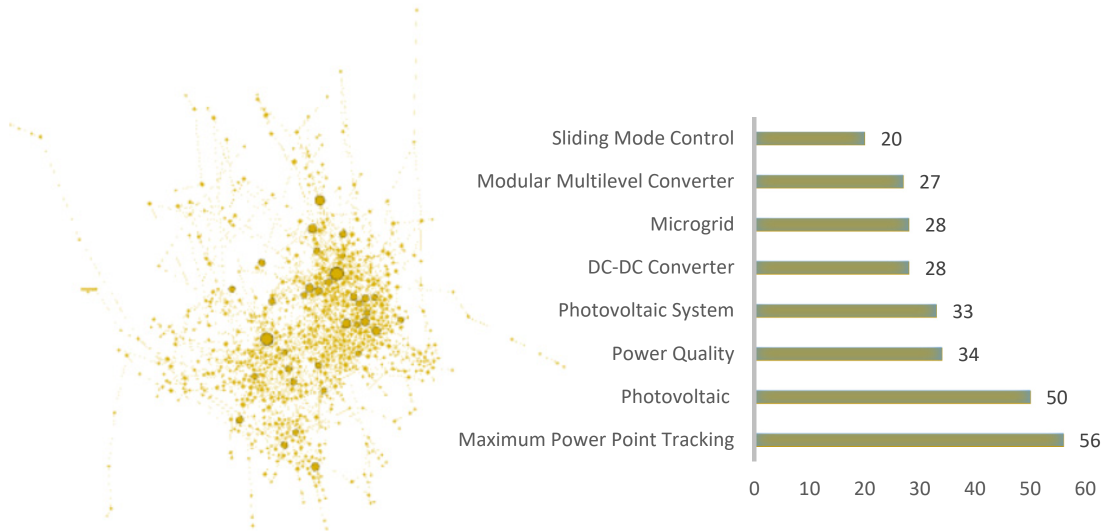
3.3.6. Optimization of the Grid Link for Renewable Energy Community

Documents in this community try to provide solutions to the different deficiencies or difficulties in the connection to the grid of renewable energy sources. This community is made up of 853 documents, with the size of this community being 8.65% of the total number of documents published. Figure 17a shows that this community has a main node which is a research paper [53]. The second and third nodes follow closely behind the main one, and both are Special Issues [11]. [54] The rest are smaller nodes:

- "Performance comparison of mismatch power loss minimization techniques in series-parallel PV array configurations" with one citation [53].
- "Power electronics in renewable energy systems" [11].
- "Photovoltaic system design and performance" with one citation [54].

The keywords of optimization of the grid link for the renewable community are shown in Figure 17b, where the top 10 are indicated with a total of 7.36% of the 4279 different keywords of this community. It also shows the number of times these words are used within the community. All the words shown in Figure 16b are related to renewable energy, such as photovoltaic (1.17%) and photovoltaic system (0.77%). The rest are for grid connection (microgrid and DC–DC converter with 0.65%, modular multilevel converter with 0. 63%, total harmonic distortion with 0.47%, distributed generation with 0.44%) and have associations with optimization terms, such as maximum power point tracking (repeated 1.3%), power quality (0.79%), and sliding mode control (0.47% of the total keywords of the community).

Photovoltaic plants are characterized by the current-voltage (I–V) curves of their modules, but the I–V characterization of the modules is complex. The mismatch produces power loss, which is known as mismatch power loss (MML). These losses can be minimized by applying algorithms to optimize the arrangement of the modules. In [53] they simulated and experimentally tested a genetic algorithm, whose results show that the photovoltaic module arrangement obtained and the current-based arrangement worked better than the arrangements obtained by all other techniques in terms of output power of the photovoltaic array and minimization of mismatch power loss. However, [55] focused on the structural analysis of mathematical models of photovoltaic cells with increasing levels of complexity. They used modelling of photovoltaic modules with one and two diodes of five and seven equivalent parameters, respectively. The modelling of the equivalent circuits is valid when assessing the trade-off between complexity and the accuracy of the photovoltaic panel model [56].



(**a**) (**b**)

Figure 17. Optimization of the grid link for renewable energy: (**a**) manuscripts published, (**b**) keywords.

Grid connections of renewable energies have stability problems, including synchronization with the frequency of the grid, converters, etc. MDPI's *Energies* journal has published a Special Issue dedicated to "Power Electronics in Renewable Energy Systems" to present innovative methods to address the stability problems observed in grid connection and the understanding of the origin of these problems [11]. Another Special Issue is dedicated to the importance of properly designing and monitoring PV systems in field to ensure good performance. This issue is called "Photovoltaic system design and performance" and addresses optimal performance and failure analysis, causes of energy loss and design, and integration issues in 21 documents published between 2017 and 2018.

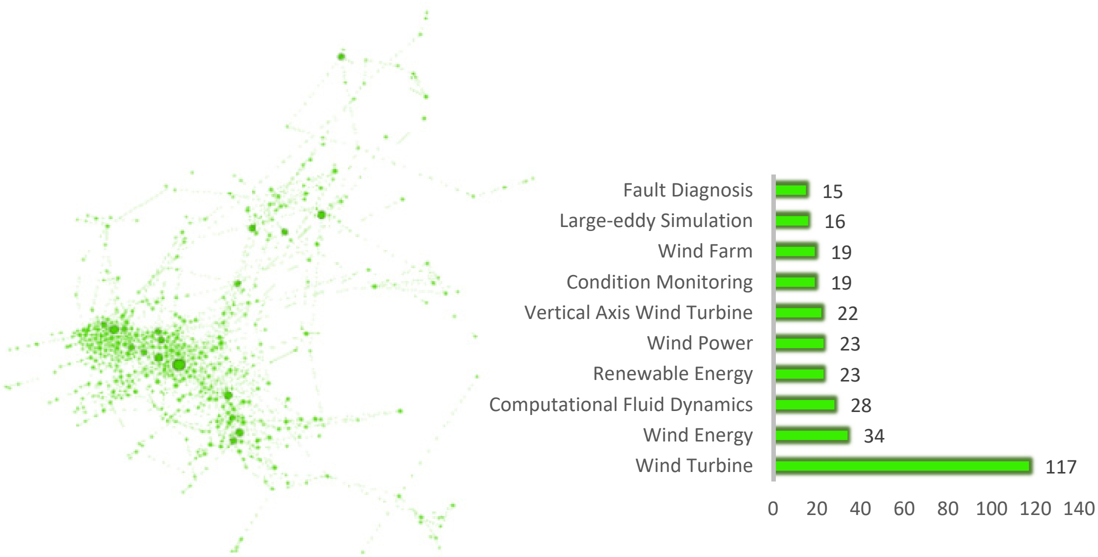
Power converters are an essential element for optimizing the efficiency of energy systems where changes in magnitude and/or phase of the signal are required. The complicated circuit topology and the high switching frequency limit the hardware use for its implementation. Reference [57] presents the field programmable gate arrays (FPGAs) that can meet the challenges for real-time simulation of hardware in the circuit of power electronics converters. The high parallelism of modern FPGAs that allows real-time simulation in nanoseconds makes it a suitable embedded system for real-time simulation of a complex power electronics system. In this work, an algorithm is presented to determine the optimal parameter of discrete time switching admittance, for which the switching loss must be minimized, and it was tested on an FPGA as a power electronics converter. The results are promising.

3.3.7. Wind Power Community

Wind energy is expanding because it is an inexhaustible and emission-free source. Large generators are exposed to harsh working conditions, which limits their life span. This community tries to collaborate by developing optimal turbine designs, methods, and innovations in the operation of wind turbines to extend the life of the turbines (20 years average) and increase their profitability for business purposes. All these considerations are linked to the technological evolution and growth of the wind market. This community is made up of 558 documents. It is the seventh-largest community with a contribution of 5.66% of published documents. Figure 18a shows a main node and eight smaller nodes; the rest have few relations. The most important node is a review of the wind turbine condition monitoring [58], and the other two documents are research articles on improvements to be applied to increase power output [59,60].

- "Wind turbine condition monitoring: State-of-the-art review, new trends, and future challenges" with 235 citations [58].
- "A numerical study of the effects of wind direction on turbine wakes and power losses in a large wind farm" with 147 citations [59].
- "Pitch angle misalignment correction based on benchmarking and laser scanner measurement in wind farms" with 12 citations [60].

The keywords of this community are shown in Figure 18b, where the top 10 are indicated with a total of 10.89% of the words of the 2902 different keywords. Among the ten most repeated are wind turbine (4.03%) and wind energy (1.17%). In addition, there are others specific to wind energy, such as wind power (0.79%), vertical axis wind turbine (0.76%), and wind farm (0.65%). The rest are words that can be shared by other renewable energies, such as hydropower.



(**a**) (**b**)

Figure 18. Wind power community layout: (**a**) manuscripts published, (**b**) keywords.

Improving energy efficiency is one of the challenges scientists face in providing solutions to growing consumption. Wind energy presents an important part of the contribution of renewables to provide solutions to the demand. Wind turbines suffer production losses due to different considerations, such as management of wind direction change, blade inclination angle misalignment errors, application of control algorithms, etc. In [59] they investigated through simulations the power loss in turbine wakes due to wind direction change. The simulations show that a small change in the angle of the wind direction can have an impact on the total energy production of the wind farm. The results of the study help to advance the changing management of wind direction in order to advance the highest energy production. In [60] they studied power loss and reduction of wind turbine life due to tilt angle misalignment in wind turbines. They used a method patented by the authors based on laser scanner measurements. Although there are several methods of tilt angle measurement, they do not obtain absolute values to improve energy production and avoid fatigue. One factor to consider is the correct functioning of the anemometer. Incorrect measurements produce a deviation from the real power curve. Then the first step is to rule out anemometer errors to focus on misalignment losses. The correct calibration of the tilt angle produces an annual increase in power output.

In these wind turbines the control system must regulate the optimal rotor speed for maximum active wind power capture, keeping the stator output voltage frequency constant and controlling the reactive power. Adequate control leads to an increase in the efficiency of the conversion system. In [61] they designed a control for a variable speed double fed induction generator (DFIG). It implements a comprehensive method of diffuse slip-mode control for control objects with uncertain parameters and force disturbances. Simulations of the control algorithm provide efficient conversion of wind energy for a wide range of wind speeds. Other authors used a control scheme based on a recurrent higher order neural network identifier (RHONN) to approximate the DC link and DFIG mathematical models [62]. Other authors worked with the squirrel cage induction generator (SCIG) and its connection to the grid [63]. They used an optimization strategy of the energy harvested from the wind using a maximum power point tracking algorithm (MPPT) implemented in fuzzy logic for the simulation of the control strategy implemented by an internal model controller (IM). The results show that it responds correctly around the expected response. In [64] they applied a hybrid control composed of a proportional-integral (PI) controller and a fuzzy logic (FLC) controller for a squirrel cage induction wind turbine (SCIG). Squirrel cage induction generators operate at fixed speeds, but have poor power quality due to transients with voltage drops, causing voltage instability. The controller improves the quality and efficiency of the resulting power and resolves voltage drops.

Wind power is based on wind turbines (WT) that need proper maintenance for safe operation and cost-effectiveness for the life of the equipment. This maintenance can represent from 10% to 20% of the total energy cost for a wind project, an important value. Reducing operation and maintenance costs, and improving reliability, are some of the challenges to be solved in this renewable energy source. The wind industry promotes the use of large wind turbines located in remote sites, which makes remote monitoring necessary. Preventive methods are used to determine the optimal point between corrective and scheduled maintenance strategies and are based on performance and/or monitoring of parameters and subsequent actions. In [58] they reviewed the methods and techniques for monitoring turbine condition. Reduced operation and maintenance costs can be achieved by a combination of preventive and reactive maintenance strategies.

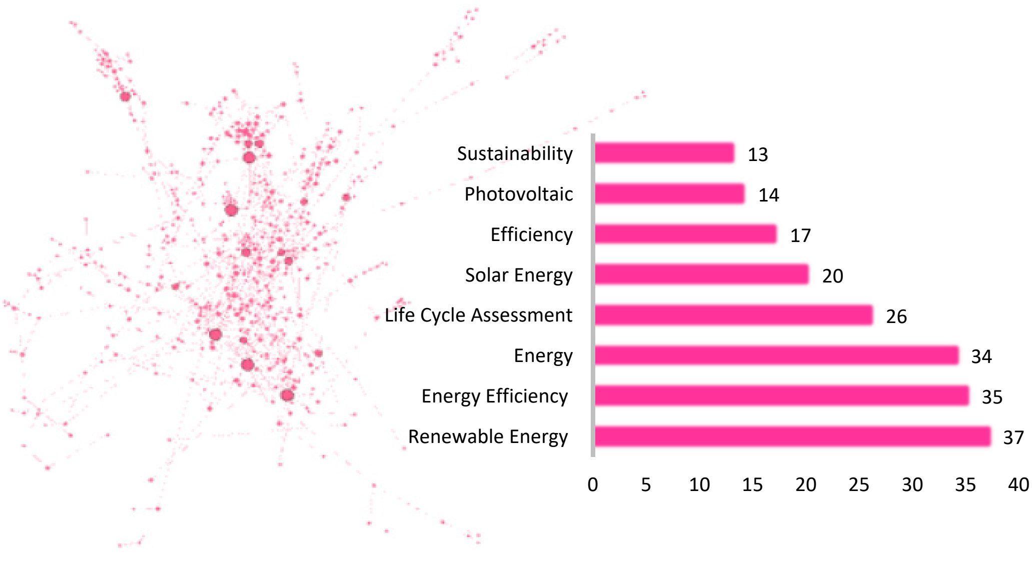
3.3.8. Sustainability of Power Systems Community

Technology provides solutions to solve energy production, but economic issues will be the ones that encourage the technology to be applied. In this community, different economic considerations are studied to analyze the viability of renewable energy sources to guide decisions on the future of energy. This community is made up of 540 documents. It is the eighth-largest community with 5.47% of published documents. Figure 19a shows five nodes of similar size, the first three of which are research articles:

- “Economic and Technical Aspects of Flexible Storage Photovoltaic Systems in Europe” with 30 citations [65].
- “Economic analysis of a photovoltaic system: A resource for residential households” with 28 citations [66].
- “What is the minimum EROI that a sustainable society must have?” with 308 citations [67].

The top 10 keywords of the sustainability of power systems community are shown in Figure 19b, which are the 7.77% of the 2830 different keywords. Among the ten most repeated is renewable energy (1.31%) which is the icon of sustainable energy. The eighth keyword is sustainability (0.46%), which is included in the name of the community. There are also renewable energies, such as solar energy (0.71%) and photovoltaic and photovoltaic system, with 0.49 and 0.39% respectively. The rest are associated with energy systems.

One approach that concerns the scientific community and governments is whether the cost–benefit analysis based on current prices is enough to guide our decisions about the future of energy. In [67] they propose energy return on investment analysis (EROI) to address the advantages/disadvantages of different fuels. They propose a minimum EROI for today's society and the derivations when that minimum is reached.



(**a**) (**b**)

Figure 19. Sustainability of power systems: (**a**) manuscripts published, (**b**) keywords.

One of the energies that has been most studied as a source of clean energy is photovoltaic energy. Photovoltaic (PV) plants, on a larger or smaller scale, can help to increase energy autonomy, tackle climate change, and promote new business opportunities. There are many studies that address this issue from an economic perspective. Relevant economic results can only be achieved when there is a harmonization between energy consumption and production. Federica Cucchiella, Idiano D'Adamo, and Paolo Rosa (2015) analyzed the economic viability of investments in industrial photovoltaic systems (200 kW, 400 kW, 1 MW, and 5 MW) in Italy without subsidies [52]. For the study they considered the net present value (NPV), the discounted recovery time (DRP), and the reduction of carbon dioxide emissions (ER cd). In addition, they considered variables such as percentage of self-consumed energy, average annual insolation rate, annual electricity purchase price, annual electricity sale price, unit investment cost, and opportunity cost. Self-consumption plays an important role in an economic framework in the absence of economic incentives, and business opportunities for industrial applications [68]. In [66] they carried out an economic analysis based on three indicators: net present value (NPV), discounted recovery time (DRPT), and levelized cost of electricity (LCOE). Then, they applied them to different plant sizes (1, 2, 3, 4, 5, and 6 kW), insolation levels (1350, 1450, and 1550 kWh/(m^{2x}y)), and shares of self-consumption (30%, 40%, and 50%). The results are profitable in all cases studied while considering self-consumption and reduction of carbon dioxide emissions. Henrik Zsiborács and collaborators (2018) carried out a study on the economic profitability from the perspective of batteries used in photovoltaic flexible storage installations in homes in 2018 in the European Union [65]. They analyzed seven cases distributed in Germany, France, Italy, and Spain with seven different types of batteries (absorbent glass mat, AGM; aqueous hybrid ion, AHI–salt water; lithium-ion, Li-ion; lithium–iron–phosphate, LiFePO4; olivine-type-lithium–iron–phosphate, olivine-type-LiFePO4; vented lead-acid battery, OPzS; sealed lead-acid battery, OPzV). The results show that the cost-effectiveness of the flexible PV system is positive, with olivine-type-LiFePO 4 and lithium-ion being the most cost-effective technologies. The authors consider that there should be unanimity in grid tariffs through a European regulatory framework with government support to encourage the implementation of flexible storage PV systems in the European market.

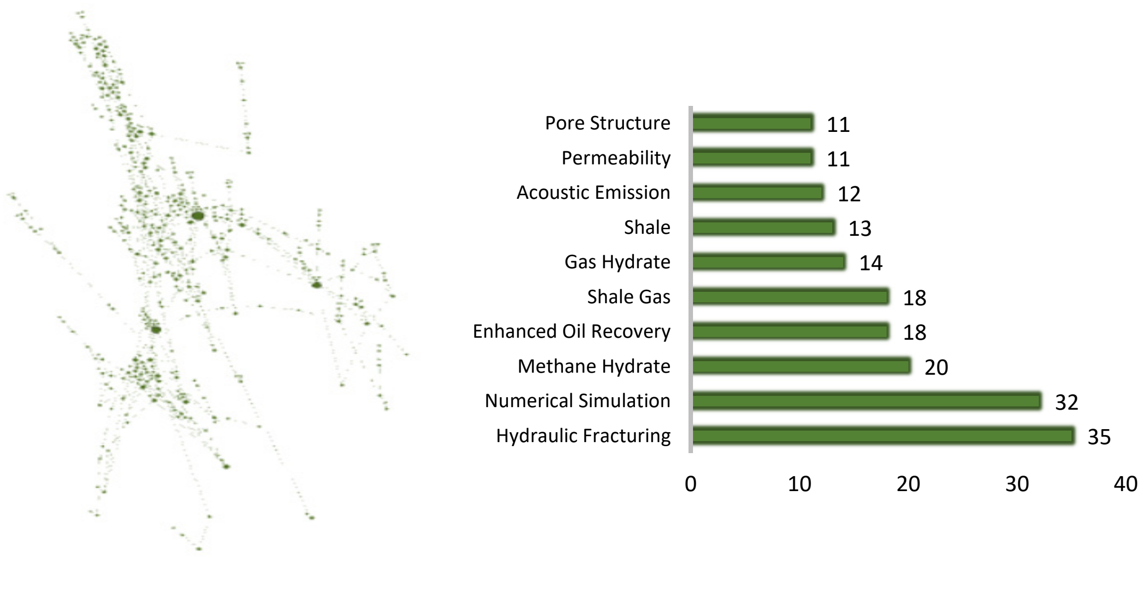
Energy efficiency plays a very important role from an economic analysis point of view, as do ecological production, efficient energy management practices, etc. This whole process requires an optimization process to improve energy efficiency in the use of resources in its different stages, with an emphasis on ecological design to extend its life. This concept is coined as integral circular integration. Reference [69] includes a review of integral circular integration to improve economic and environmental exploitation with the analysis, modelling. and optimization of the processes included in the 21st conference on Process Integration, Modelling and Optimization for Energy Saving and Pollution Reduction (PRES 2018).

3.3.9. Hydrocarbon Improvements Community

Oil fields are depleting their reserves, and no new fields can be found to meet the demand. This community investigates the methods, models, and processes of safe and efficient extraction of non-conventional resources to solve the increasing demand for fossil fuel consumption.

This community hosts 229 documents. It is the ninth-largest community with a contribution of 4.46% of published documents. Figure 20a shows that there are three larger nodes, and the rest are poorly related. These three nodes are two editions of a Special Issue in 2019 and a review in 2010:

- "Recent advances in flow and transport properties of unconventional reservoirs" with two citations [70].
- "Emerging advances in petrophysics: Porous media characterization and modelling of multiphase flow" with three citations [71].
- "Enhanced oil recovery: An update review" with 439 citations [72].



(a) (b)

Figure 20. Hydrocarbon improvements: (**a**) manuscripts published, (**b**) keywords.

Figure 20b shows the top 10 keywords of the hydrocarbon improvements community with 8.19% of the 2246 different keywords. All the keywords are specific to this community, with hydraulic fracturing standing out (1.56%).

Over the years, fewer oil fields are being discovered and demand is increasing, which worries governments and oil companies. One possible solution is to implement improved oil recovery methods. These methods reflect advances in drilling and well technologies, intelligent reservoir management and control, reservoir monitoring techniques, and the application of various improvements in the primary and secondary recovery processes. Reference [72] presents a review of improved oil recovery methods, such as thermal methods; injection methods of high pressure air (HPAI), hydrocarbon gas, and CO_2; chemical EOR methods; and combinations of compliance technologies (gel treatments) to improve injection profiles and sweeping efficiency with chemical EOR flooding. It also analyzed their applications in different parts of the world.

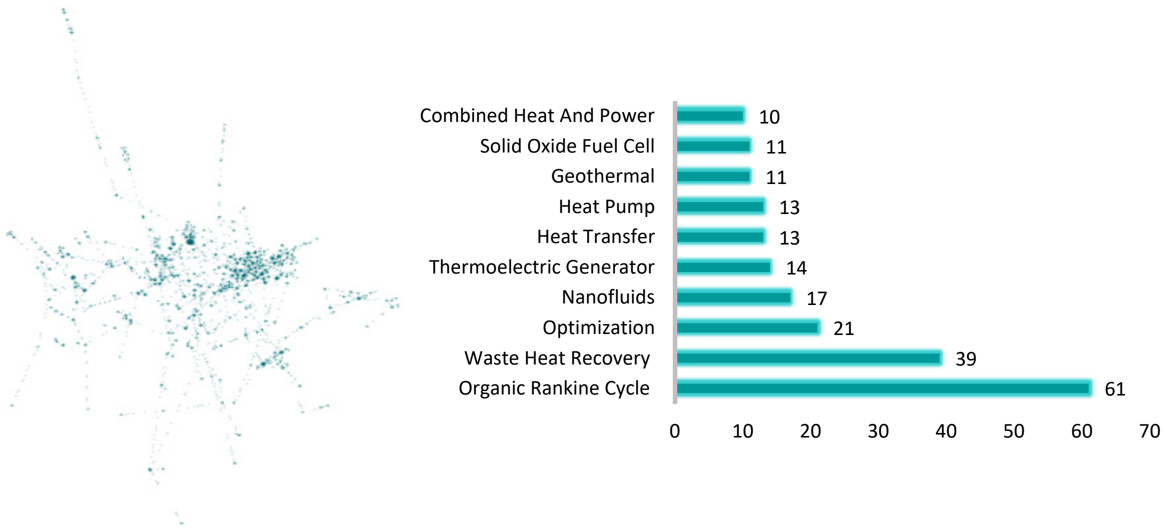
The researchers are working on how to obtain energy resources and exploit them following evidence of the presence of natural gas hydrates containing large amounts of methane and other lighter hydrocarbons [73]. However, exploitation poses challenges, such as the fact that natural gas hydrates remain stable as long as they are in mechanical, thermal, and chemical equilibrium with their environment, and their extraction breaks some state of equilibrium. Depressurization and thermal or chemical stimulation can be used alone or in combination. In [74] they simulated the thermal stimulation of hydrate-bearing sediments for in situ hydrate combustion. The proven method is different from the conventional ones used in oil extraction. The results were encouraging.

Other contributions to solving oil reserve shortages are unconventional resources such as shale, coal, and waterproof sandstone deposits. To make their extraction profitable, new extraction techniques and geophysical and geochemical methods need to be applied to characterize petrophysical properties, fluid transport, and their relationships at multiple scales to improve production efficiency. MDPI's *Energies* journal proposed two Special Issues in 2019 to address unconventional fuel resources. In the Special Issue "Recent advances in flow and transport properties of unconventional reservoirs," Jianchao Cai and contributors review the 22 contributions published in this Special Issue to address this topic in depth. The review covers petrophysical characterization, hydraulic fracturing, fluid transport physics, improved oil recovery, and geothermal energy for unconventional reservoirs, for [70]. In the Special Issue "Emerging Advances in Petrophysics: Porous Media Characterization and Modeling of Multiphase Flow," Jianchao Cai and collaborators review 15 publications collected in this Special Issue devoted to experimental studies of petrophysical property characterization for unconventional resources, numerical modeling (fractal approach), and multiphase flow modeling/simulation of unconventional resources [71]. Following this theme [75], mathematical heat and mass transfer models were developed to investigate the reliability problems generated by large temperature or pressure differences. They considered the influences of the physical properties of the porous substrate, physical properties of the working fluid, arrangement of the holes, and parameters of the hole structure on the characteristics of flow and temperature field.

3.3.10. Conversion of Thermal/Electrical Energy Community

This community is investigating the use of thermal energy from different sources to produce electrical energy. It is made up of 418 documents and is the tenth-largest community with 4.24% of the documents published. Figure 21a shows that there is only one medium sized node [76], and the rest have poor relations, the three largest nodes being:

- "Geothermal energy: Delivering on the global potential" with 11 citations [76].
- "Comparison of different solar-assisted air conditioning systems for Australian office buildings" with 11 citations [77].
- "Combinatory finite element and artificial neural network model for predicting performance of thermoelectric generator" with three citations [78].



(**a**) (**b**)

Figure 21. Conversion of thermal/electrical energy: (**a**) manuscripts published, (**b**) keywords.

This community uses 2095 different keywords. Figure 21b shows the top 10 with a percentage of 10% of keywords. Within the most representative keywords are those specific to heat-to-electricity conversion, such as organic Rankine cycle (2.91%), waste heat recovery (1.86%), nanofluids (0.81%), thermoelectric generator (0.67%), heat transfer (0.62%), heat pump (0.62%), geothermal (0.53%), solid oxide fuel cell (0.48%), and solar energy (0.48%). The only one that does not represent heat conversion directly is optimization (1.00%), but this word includes the application of information technologies to energy conversion. All current conversion systems allude to optimization as a method of improving system efficiency, improving cost, and lessening maintenance and system management, and in all of them there is an implication of optimization algorithms.

Improving energy efficiency is a priority to reduce adverse effects on the environment. In addition, there is a growing concern about finding power sources. One solution to both questions is renewable energy sources, which requires research into different alternatives for obtaining energy. Obtaining electrical energy through thermal energy has given rise to this community which proposes different types of heat-to-electricity conversion. Geothermal energy forms part of renewable energies, although its exploitation is far behind other renewables such as solar or wind energy. The main disadvantages associated with its commercial exploitation are the high initial investment and uncertainties regarding the availability of resources. However, the gap between the disadvantages is narrowing. The latest techniques for characterizing deposits have reduced the uncertainty regarding the availability of resources, and adequate management of drilling reduces initial capital expenditure [76].

Another source of energy is thermoelectric power generation through direct conversion of heat into electricity. The main drawback is that the heat-to-electricity conversion efficiency of thermoelectric generators (TEG) is up to 11% in laboratory environments; it is much lower in practice. In [78] they propose a model based on artificial neural networks that can predict the performance of an TEG on demand. The model evaluated predicts the performance of an EEG at 26.4 ms per data point compared to the 6.0 min required in traditional simulations.

Another alternative for electricity production is the application of techniques for the recovery of waste heat. Recovery plants based on the organic cycles of Rankine (ORC) are a solution, although their application is not always profitable for small and medium scale use; the low temperature of the available heat source implies a low efficiency of the thermodynamic cycle. Lorenzo Tocci and collaborators (2017) carried out a review of this technology. They studies the expander as a key element for small-scale energy production [79]. In [80] they used this ORC technology to recover the residual heat contained in the exhaust gases of a biogas engine.

On the other hand, another way to reduce energy consumption is to contribute to the best application of available electrical energy. The construction sector is responsible for 32% of total primary energy consumption in the world—40 % in the U.S. and E.U. [81]—in addition to a very important share of CO_2 emissions, above 30%. This has attracted the attention of the scientific community, which aims to provide short-term solutions to this global problem. From this perspective, a large part of this energy is the conditioning of the environment in buildings. In [77] they have investigated the feasibility of four different air conditioning systems (solar evaporative desiccant cooling system, hybrid solar desiccant compression cooling system, solar absorption cooling system) and a conventional variable air volume (VAV) vapor compression system for comparison. The study was conducted using Energy Plus building energy simulation software. For this study, combined solar energy collection systems and with one application each, such as air conditioning, are used. The experiment has been applied to office buildings in all eight Australian capitals. The results are not homogeneous, since in two provinces the system by solar desiccant evaporation achieved annual energy savings of 56.9 and 82.1% and annual reductions of CO_2 emissions of 97.24 and 178.45 tons. On the other hand, in the remaining six solar absorption cooling systems it is the most efficient with the greatest annual reduction in CO_2 emissions. In all cases the three combined systems were more efficient and environmentally friendly than the conventional system, although from an economic point of view it was not economically profitable in all provinces to change over to the conventional system, due to the high initial investment and the low performance that produces low energy saving potential.

3.3.11. Electric Motor Advances Community

Electric motors are very useful with renewable energies and sustainable transport with electric vehicles. There are increasing advances in these motors with the aim of increasing efficiency and eliminating modelling difficulties in order to extend the scope of use. This community shows the advances in electric motors with case studies in the design of generators for wind energy, wave and hydroelectric power, electric cars (EV), etc. This community is composed of 338 documents and is the eleventh-largest community with a contribution of 3.43% of published documents. Figure 22a shows 15 nodes highlighted by their relations in the community. The three largest nodes correspond to two research articles that promote improvements in synchronous motors [82,83], and the third document is the promotion of a Special Issue that covers permanent magnet synchronous machines and the electrical systems to which they are connected in different areas of application [84]:

- "Investigation of a Novel 24-Slot/14-Pole Six-Phase Fault-Tolerant Modular Permanent-Magnet In-Wheel Motor for Electric Vehicles" with 38 citations [82].
- "Sensorless energy conservation control for permanent magnet synchronous motors based on a novel hybrid observer applied in coal conveyer systems" with one citation [83].
- "Permanent magnet synchronous machines" without citations [84].

Figure 22b shows the top 10 with a percentage of 10.13% of keywords 1728 different keywords. All the words are specific to this community, although the most representative are electric vehicle (1.45%) and hybrid electric vehicle (0.69%), as the development of these vehicles has driven innovation in the engines they incorporate.

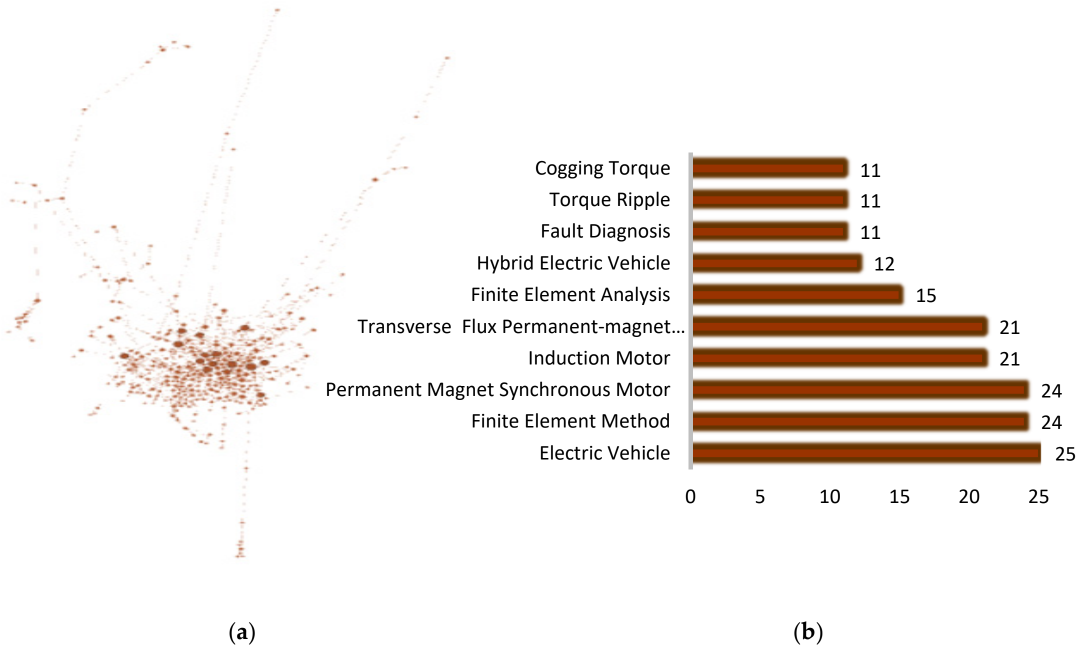


Figure 22. Electric motor advancements: (**a**) manuscripts published, (**b**) keywords.

The scientific community is investigating how to improve energy systems from different perspectives. In this area, there are main work topics, such as improving the operation and efficiency of electric utility motors in the field of renewable energies, the traction of electric vehicles and conveyor belts in industry, etc. Reference [82] proposes six-phase fault-tolerant modular permanent magnet synchronous motors (PMSM) with a combination of 24 slots/14 poles for electric wheel drive vehicle applications. The results show that an optimal design results in low eddy current losses. Liang and co-workers (2016) proposed an analytical method of calculating the inductance of the d and q axles for internal permanent magnet (IPM) motors with V-shaped rotors in no-load conditions. The utility is to improve the efficiency of internal permanent magnet (IPM) motors used in an electric vehicle [85]. The proposed method was verified with a 48-slot/8-pole IPM motor with a V-shaped rotor.

Early failure detection is another concern of this community. The most likely fault in large synchronous generators is a short-circuit in the rotor winding, which results in increased excitation current and rotor vibration. The main drawback is that at an early stage the excitation current between windings is small, which does not help in its detection, but if the fault persists it can cause a serious accident and represent a great threat to a safe operation of the generator and the power grid. Reference [86] presents a method of online fault identification based on the identification of the Volterra core. Stator branch voltage and stator unbalance branch current collected from the generator are used for detection. The identification of the short circuit fault occurs by analyzing the time domain of the non-linear transfer model.

Shun Li and Xinxiu Zhou (2018) proposed a reference model to estimate the rotor speed and position in the starting stages in PMSM to drive coal conveyors [83]. They use a hybrid observer (start-up estimation algorithm and operation estimation algorithm) for accurate estimation of rotor speed and position from start-up to operation. The speed estimation algorithm achieves the most efficient conversion of electrical energy.

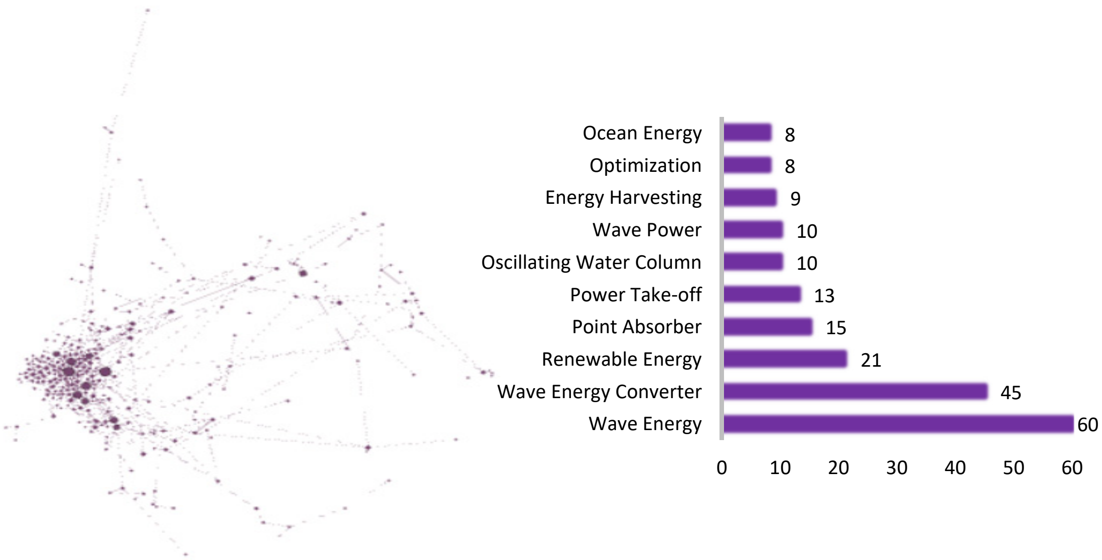
MDPI's *Energies* journal addresses all concerns and improvements on the topic of "permanent magnet synchronous machines" in a Special Issue. Reference [84] reviews the fifteen contributions of the Special Issue. The contributions have contributed to innovations in electrical machines in two main areas, renewable energies and electrical transport.

3.3.12. Marine Renewable Energy Community

Energy production technologies based on wind, waves, and tides present successful alternatives for renewable energy collection in the oceans and seas. These technologies are abundant, with inexhaustible resources, and they are the basis of renewable energy free of emissions. This presents a great alternative for solving the problems of increased energy consumption and helping to solve some of the problems caused by traditional energy extractions related to climate change, and moves towards a sustainable and ecologically-friendly energy future. Although offshore wind energy collection is proving very successful, wave and tidal based systems have few commercially implemented projects. This may be due to the immaturity of the technology, energy production costs, lack of investor confidence, politics, etc. This community presents different investigations carried out that show that this type of technology is viable, although it requires technological maturity to obtain greater returns from commercial exploitation.

This community is made up of 286 documents. It is the twelfth-largest community with a contribution of 2.90% of published documents. Figure 23a shows that there are two major nodes and four slightly smaller ones according to the number of relationships they have with the community or between communities. Of the three most prominent nodes, there are two case study articles on the Gulf of Mexico [87] and the Portuguese coast [88]. The third is an editorial call for a Special Issue to address contributions to energy extraction from the seas and oceans [18]:

- "Assessment of the potential of energy extracted from waves and wind to supply offshore oil platforms operating in the gulf of Mexico" with five citations [87].
- "Evaluation of various technologies for wave energy conversion in the Portuguese nearshore" with 121 citations [88].
- "Special Issue "offshore renewable energy: Ocean waves, tides and offshore wind" with one citation [18].



(**a**) (**b**)

Figure 23. Marine renewable energy: (**a**) manuscripts published, (**b**) keywords.

The top 10 keywords of the marine renewable energy community are shown in Figure 23b; these 10 words form 12.76% of 1559 different keywords. Among the ten most repeated is renewable energy (1.35%), as it forms part of the name of the community complemented by ocean energy (0.51%).

The calculation of the power delivered forecast is one of the concerns of this community and is shown by the repetition of wave energy (3.85%) and wave power (0.64%).

Electrical power is required in different places on Earth, but sometimes it is not accessible from the ground, so alternative electrical systems are required. One case is oil platforms far from the coast. For this application, independent electrical systems with gas turbines are used to generate their own electricity. The main disadvantage of these systems is that they are inefficient due to the variable conditions at sea, resulting in increased fuel costs and pollutant emissions. Wave energy is an alternative to consider, as it can be predicted more reliably than wind or solar energy, although less so than tidal energy. The main drawback is that adequate predictive modelling of the energy extraction site is required to obtain an efficient system. The reliable estimation of wave energy and of the global tide is evaluated using multivariate numerical models. There are different methods of obtaining wave energy, but their efficiency depends largely on the detailed study of the possible extraction sites conditions based on the wave height and energy period to use the appropriate system for the estimated conditions. In [88] the performances of various wave energy technologies in the Portuguese coastal environment were evaluated. For modelling, they used data recorded from three previous years (2009–2011) and applied prediction algorithms according to wave height and energy period, for the winter season and for full years. From the experiments they drew several significant conclusions, such as that the energy extracted is dependent on the sea states between different periods and not only on the average wave energy. This results in some locations being more suitable than others nearby and some technologies being more efficient than others depending on the location. Eugen Rusu (2014) evaluated wave energy resources in several coastal areas (Iberian coast, its islands, and its archipelago) with the aim of finding suitable locations for commercial exploitation [89]. In the analysis, he also used the bivariate system of wave height and period of energy, as in other works [88]. Eugen Rusu considers that in order to increase energy efficiency, a previous study should be done and the dispersion diagram showing the bivariate distribution of the specific sea states of the coastal area where the wave energy converters are going to operate should be obtained. Another consideration for increasing efficiency is to design adjustable power wave energy converters for adaptation to site-specific conditions.

In [90] they propose an alternative to the wave energy converter (WEC) called Wavestar WEC. The system uses an almost lossless power take-off (PTO) system of energy-absorbing cylinders, which converts the wave-induced movement of the floats into a constant power output to the grid. The authors modelled more than 600 states in different irregular seas with conversion efficiencies greater than 70% for all relevant sea conditions.

In [87] they recommend a methodology for a hybrid electricity supply system for offshore oil platforms in the Gulf of Mexico. They analyzed three different options (wind energy, wave energy, and wind-combined wave energy) and atmospheric data from the area. The results showed that wind or wave energy gave acceptable levels, although the combined one presents better efficiency and admits more adaptation to the locations.

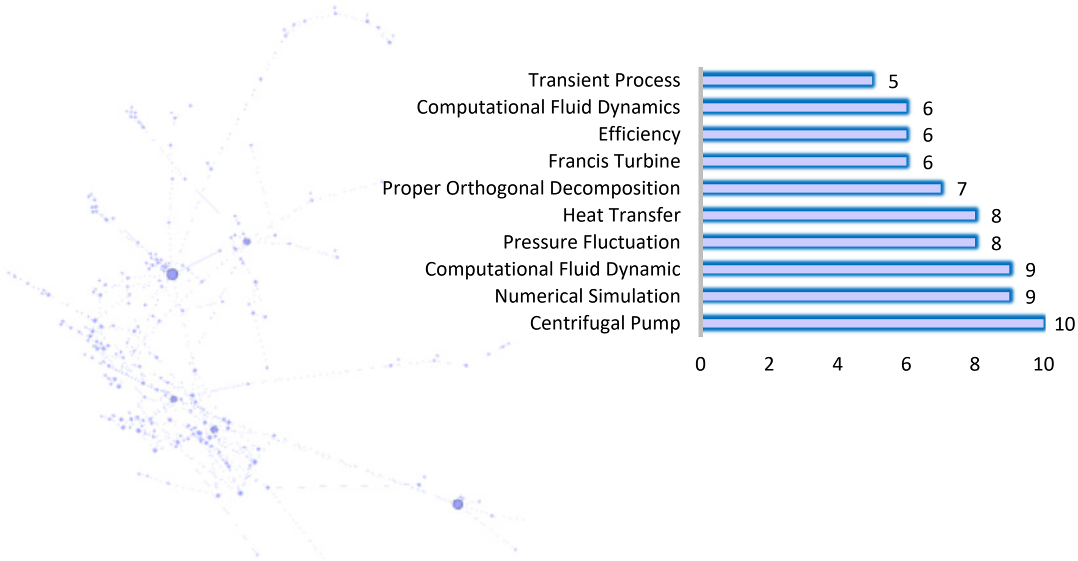
In [18] they propose a Special Issue to reflect the state of research in marine energy collection. The aim of this Special Issue would be to provide a scientifically based overview of new methodologies, modelling techniques, software tools, optimization methods, laboratory tests of technologies, etc., used in offshore renewable energy.

3.3.13. Hydropower and Energy Storage Community

Hydroelectricity is a widespread energy conversion system, as it achieves safe, stable operation and efficient conversion of electricity. There are currently large hydroelectric power plants (HPPs) distributed throughout the world, but as the number of HPPs increases, so does the complexity of the structure of the hydraulic-mechanical-electric system to obtain more efficient conversion. Small or micro hydroelectric plants have also increased. In order to obtain efficient production, control strategies, transitory states, modeling, and dynamic responses of turbines, pumped storage systems, etc., are being studied. This community is made up of 229 documents. It is the second smallest community with a contribution of 2.32% of published documents. Figure 24a shows two major nodes and three minor ones. The three nodes with the highest ratios are two editions of a Special Issue and a research paper:

- Special Issue "fluid flow and heat transfer" without citations [91].
- "Advanced energy storage technologies and their applications (AESA2017)" without citations [19].
- "Optimization of guide vane closing schemes of pumped storage hydro unit using an enhanced multiobjective gravitational search algorithm" with 18 citations [92].

Figure 24b shows the top 10 keywords with a percentage of 6.45% of 1148 different keywords. All the words are specific to this community and three of them are from computational techniques—numerical simulation (0.78%), computational fluid dynamic (0.78%), and computational fluid dynamics (0.52%).



(**a**) (**b**)

Figure 24. Hydropower and energy storage: (**a**) manuscripts published, (**b**) keywords.

Renewable energies do not have homogeneous generation, which makes a backup through storage energy sources necessary. Pumped storage plants (PSP) for wind and solar energy are usually the most common storage means, as they solve the randomness and heterogeneity of wind and solar energy generation. It helps to improve the reliability and quality of the electricity grid and promotes the integration of different renewable energies. The hydraulic pumped storage units (PSHU) must solve several dynamic problems in non-optimal operation conditions, such as load rejection or pump interruption, increases of the unit rotation speed, and increases of water hammer pressure when above the maximum design value. They can cause leakage, abnormal vibrations, and other negative phenomena. Optimization of guide vane sealing schemes (OGVCS) is an important means of solving regulation and ensuring pumped storage calculation, and is also the preferred method for optimizing the hydraulic transient process. Modelling for the optimization of guide pallet closure schemes (OGVCS) of hydraulic pumped storage units (PSHU) can guarantee the safety and stability of the electricity network. In [92] they propose a multitarget OGVCS model to optimize conflicting objectives, such as raising unit rotation speed and lowering water hammer pressure. The proposed model considers the rate of unit rotation speed increase, the specific node pressure of each hydraulic unit, and several complicated hydraulic and mechanical constraints.

MDPI's *Energies* journal covers a Special Issue of "Advanced energy storage technologies and their applications" applied to promote the advancement of electric vehicles and renewable energies.

Reference [18] reviews 22 contributions to the Special Issue. Contributions have been made through new materials and energy storage devices at different scales and topologies; applications in electric traction systems; modelling, simulation, optimization, and management of energy storage systems, including testing and modelling of ageing processes, life cycle analysis, reuse, and recycling; and business models for energy storage applications and deployment.

In 2017 a Special Issue dedicated to "Engineering fluid dynamics" was published, covering computational fluid dynamics (CFD) and experimental fluid dynamics (EFD) methods. This topic has been applied to different areas of engineering, such as vehicle aerodynamics, and is currently applied to chemical engineering, renewable energies, etc. Its greatest expansion has been due to the incorporation of open-source systems, which has allowed the easy adaptation of the algorithms to new challenges. The twelve documents published in this Special Issue are summarized in [93]. In this issue, the document "A Performance Prediction Method for Pumps as Turbines (PAT) Using a Computational Fluid Dynamics (CFD) Modelling Approach" was published [94], wherein a new method for predicting the inverse characteristic of industrial centrifugal pumps was proposed. This method has applications in the small hydroelectric systems that produce electric energy with the use of pump as turbine (PAT) with a low cost, low maintenance, and low environmental impact. A CFD model was designed while considering the specific height, capacity, power, and efficiency. With the application of the model, they found the best efficiency point of all the analyzed pumps.

Another Special Issue was entitled "Fluid Flow and Heat Transfer," applied in the areas of science and engineering. Reference [91] reviewed 25 contributions from the Special Issue. The contributions have contributed to the behavior, methods, model analysis, applications, etc., grouped into the following sub-themes: turbomachinery and boundary layer flow; heat transfer and heat exchangers; two-phase flow; flow with micro and nano scale; characteristics and various problems in the context of energy systems.

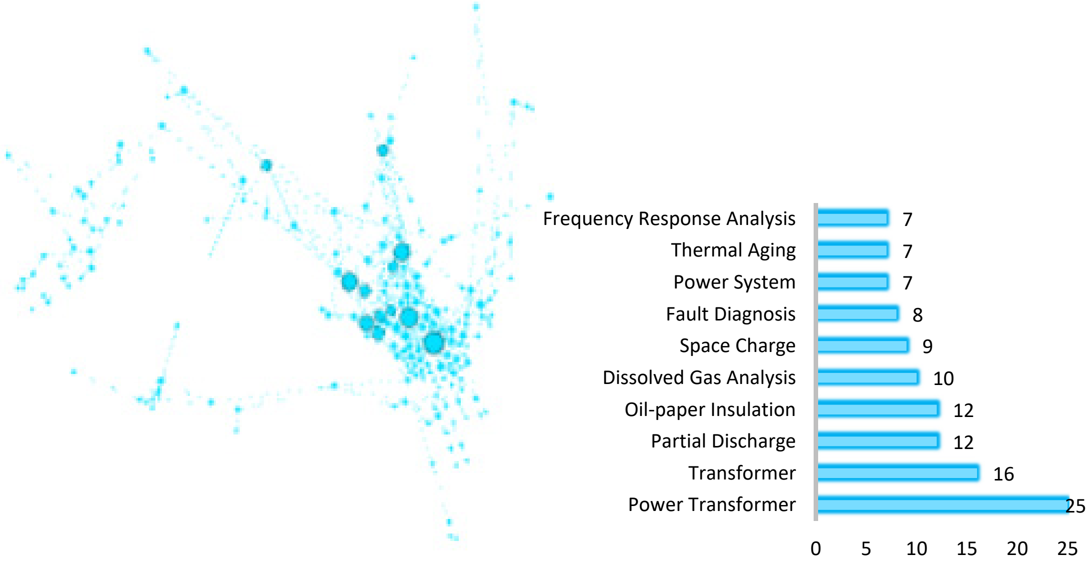
3.3.14. Preventive Techniques in Power Transformers Community

This community is composed of 193 documents. The primary equipment of the electrical networks, such as power transformers, play a very important role in the distribution network, where a break leaves a distribution line without service. Monitoring the state of insulation is a priority in order to reduce malfunctions and their impacts on the electricity distribution service. This community is studying techniques and tools to detect insulation faults early and reduce their impacts on the distribution network. It is the smallest community with a contribution of 1.96% of published documents. This community has four nodes with greater relationships, as can be seen in Figure 25a:

- "Review of physicochemical-based diagnostic techniques for assessing insulation condition in aged transformers" with 57 citations [95].
- "Diagnostic measurements for power transformers" with 67 citations [96].
- "Dissolved gas analysis principle-based intelligent approaches to fault diagnosis and decision making for large oil-immersed power transformers: A survey" with 19 citations [97].

This community uses 1018 different keywords. Figure 25b shows the top 10 with a percentage of 11.10% of keywords. Among the most representative keywords are the specific ones that give the community its name, such as power transformer (2.46%) and TRANSFORMER (1.57%); the rest are techniques for power transformer failure prevention.

Transformers are an essential part of the primary electrical network's equipment, so an important part in the phase of distribution of energy through the electrical network. This equipment requires maintenance in order to reduce the rate of internal failures. In [98] the authors review the effect sof loads and other key factors on the ageing of the oil transformer. Radu Godina and collaborators (2015) considered that a monitoring system is essential to guarantee the reliability and sustainability of the transformer and proposed the technique of online monitoring of the transformer by controlling the winding temperature or through dissolved gas analysis.



(**a**) (**b**)

Figure 25. Preventive techniques in power transformers community: (**a**) manuscripts published, (**b**) keywords.

Diagnostic techniques are classified as offline or online. Offline techniques require the disconnection of the equipment from the network, which is rarely done under planning and with the suspicion of failure, having consequences on the service. On the other hand, online systems allow real-time monitoring without disconnection; the analysis of the data recorded can predict a failure early, thereby reducing the impact on the network. In [95,96] they review the precise diagnostic methods for analyzing the status of transformers. Lack of internal transformer insulation is the main cause of breakdowns. Transformer monitoring uses electrical and physicochemical diagnostic techniques to observe the state of power transformer insulation. The results from [95] show that oil can be very suitable for analyzing the condition of power transformers. In [96] provides tutorials supported by case studies, results that lead to more efficient maintenance strategies.

A diagnostic tool for predicting the ageing condition of transformer oil paper insulation is the polarization–depolarization current (PDC) measurement. In [99], Yiyi Zhang and collaborators applied PDC, and their results show that large time constants can be considered as an indicator of ageing, and a correlation could be made for quantitative assessment of ageing in transformer cellulose insulation.

Lefeng Cheng and Tao Yu (2018) discussed intelligent fault diagnosis and decision-making tools with existing problems and solutions for large oil-immersed power transformers based on dissolved gas analysis (DGA) [97]. The results show that in order to avoid optimal local failure, several intelligent algorithms must be combined to form a hybrid fault diagnosis network. In addition, improved gas detection instruments are required to obtain reliable data for analysis correlated to the transformer status.

3.4. Author Analysis, Affiliations, and Countries of Publication in MDPI's Energies Journal

There are 27,863 authors from 118 countries investigating in 14 different areas who have published in MDPI's *Energies* journal. The twenty countries with the highest concentrations of researchers contributing to their scientific publications in MDPI *Energies* journal have been analyzed and represented in Figure 26. In total, 23,566 researchers come from said countries (85.16%). The main contribution is made by China, with 10,171 researchers (36.75% of the total), followed by South Korea with 1913 (6.91%), and the United States 1617 (5.84%). The following countries in the ranking belong to the European Union with 5454 researchers (19.71%): Spain is the European country with the highest contribution of researchers, with 1553 scientists (5.61%), followed by Italy with 1529 researchers (5.53%), and then closely by the 926 of the United Kingdom (3.35%). The rest of the European countries have the following contributions: 875 researchers in Germany (3.16%), 335 in Sweden (1.21%), 326 in Denmark (1.18%), 312 in Poland (1.13%), 264 in Belgium (0.95%), and 260 in France (0.94%). The rest of the authors are dispersed around the world, contributing to less than 3% of the total of the authors; the nearest case is Taiwan with 828 researchers (2.99%).

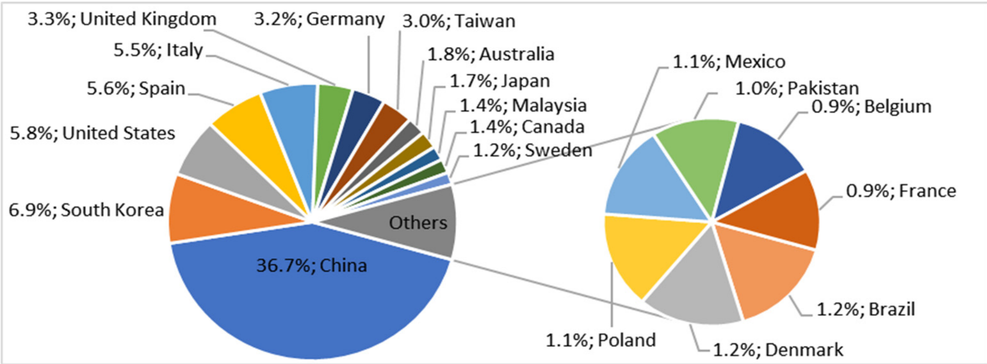


Figure 26. Author distribution by top 20 countries (85.16% of the total).

In Figure 27 the distribution of authors' participation can be observed according to the country of origin—the darkest country being the one with the greatest contribution of researchers. On the map you can see that Africa is where there is the highest concentration of countries that do not publish in MDPI's *Energies* journal is.

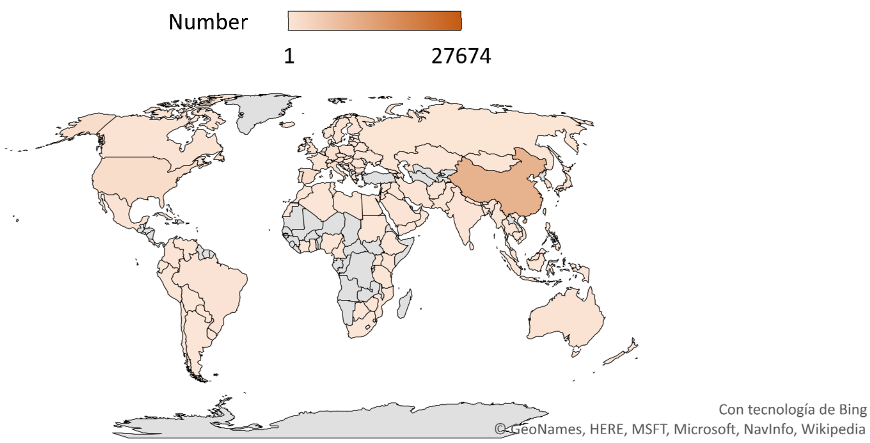


Figure 27. Author distribution by country.

There are 101 countries with a percentage contribution less than 1% of the global number, with a contribution of 17.71% of the total, such as Pakistan, Belgium, France, and Portugal—among others—with percentages of 0.9% each. The results show that both the United States and Asian countries are actively collaborating on progress by building partnerships with other countries to move forward, as can be seen in the intertwining of communities.

Table 2 shows a list of the top 20 authors with the highest H-index values according to Scopus from MDPI's *Energies* journal, of which only seven have an H-index above 100, and none correspond to China, which is the country that publishes most in MDPI's *Energies* journal. The top Chinese authors are in eighth, tenth, and fifteenth position. If this table is compared with the countries with the largest contributions from the authors (Figure 26), there is no direct correspondence between the two. South Korea has the author with the highest H-index of 136, R. Ruoff (ID 7004442771), and they have J. Lee

(ID 26643592500), who ranks 20th with an H-index of 74; and South Korea was the second country to publish in MDPI's *Energies* journal. The United States has five representatives in the top 20 in positions 4, 5, 9, 12, and 15 with H-indexes ranging from 114 to 83, and it is the third largest contributor. Of the 20 countries that publish most in MDPI's *Energies* journal, only nine are represented in Table 2, where there also appears to be an author from Israel—S. Havlin (ID 35397372900) with an H-index of 104. Israel has 18 authors (0.06%) and is in position 63 of the 118 countries. Chile occupies the opposition 37 of the countries with 90 authors (0.32%), and is represented in the top 20 of authors by the researcher J. Rodríguez (ID 57203271100) with an H-index of 77. If we analyze the first three authors in Table 2:

- R. Ruoff (ID 7004442771) has available an article with more than 10,000 citations [100] and another with more than 9000 citations [101]. Additionally, he has published with 156 different contributors.
- Yoshio Bandô (ID 7202285914) is the second largest H-index author and has articles with 1300 citations [102]. He has collaborated with 159 different authors.
- Blaabjerg F. (ID 7004992352) is the third largest H-index author and has articles with 3200 citations [103]. He has collaborated with 159 different authors.

Table 2. Distribution of the authors according to the H-index.

Scopus ID	Indexed Name	H-Index	City	Country	University
7004442771	Ruoff R.	136	Ulsan	South Korea	Ulsan National Institute of Science and Technology
7202285914	Bando Y.	121	Tsukuba	Japan	National Institute for Materials Science Tsukuba
7004992352	Blaabjerg F.	114	Aalborg	Denmark	Aalborg Universitet
55762454700	Logan B.	114	University Park	United States	Pennsylvania State University
7101966137	Haddon R.	111	Riverside	United States	University of California, Riverside
35397372900	Havlin S.	104	Ramat Gan	Israel	Bar-Ilan University
7006586066	Ariga K.	101	Tsukuba	Japan	National Institute for Materials Science Tsukuba
36078440500	Wang J.	98	Beijing	China	Beihang University
57189710804	Amine K.	98	Argonne	United States	Argonne National Laboratory
55955529900	Zhu J.	92	Nanjing	China	Nanjing University
8856998000	Hayat T.	86	Islamabad	Pakistan	Quaid-i-Azam University
7102851356	Curtiss L.	86	Argonne	United States	Argonne National Laboratory
23017714200	Bonamente E.	85	Perugia	Italy	Università degli Studi di Perugia
35549251600	Lipo T.	83	Tallahassee	United States	Florida State University
7102165827	Nan C.	81	Beijing	China	Tsinghua University
57203271100	Rodríguez J.	77	Santiago	Chile	Andres Bello National University
7005453080	Passerini S.	76	Ulm	Germany	Helmholtz Institute Ulm
24783103100	Hultman L.	74	Linkoping	Sweden	Linköpings universitet
35588010400	Guerrero J.	74	Aalborg	Denmark	Aalborg Universitet
26643592500	Lee J.	74	Pohang	South Korea	Pohang University of Science and Technology

Figure 28 shows the distribution of H-indexes of the 27,883 authors published in MDPI's *Energies* journal who were selected for this study. The highest concentration is for authors with low H-indexes in the range of 0–9, with 20,318 authors (72.87% of the total), of which 2403 have an H-index of 0 and 4764 have an H-index of 1. The next two ranges of 10–19 and 20–29 have 17.77 and 5.99% of the total, respectively. From 30 onwards the number of authors decreases considerably below 2%, until it is reduced to one author for the last ranges of 120–129 and 129–139.

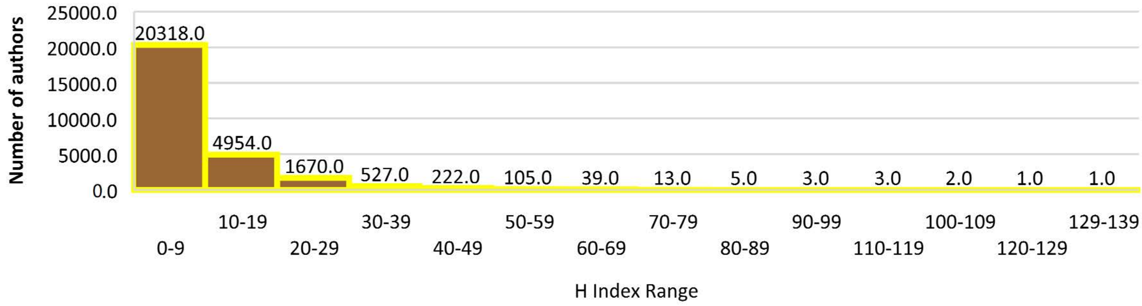


Figure 28. Distribution by H-index.

3.5. Analysis by Documents Type in MDPI's Energies Journal

Figure 29 shows the distribution of the different publication formats of the documents found in the Scopus search. Articles are 95.02% of the total documents found (13,925 documents); 4.28% are Reviews (627 documents). The rest have a total contribution of less than 1%. These results are like those found in other works [104]. All documents are published in English.

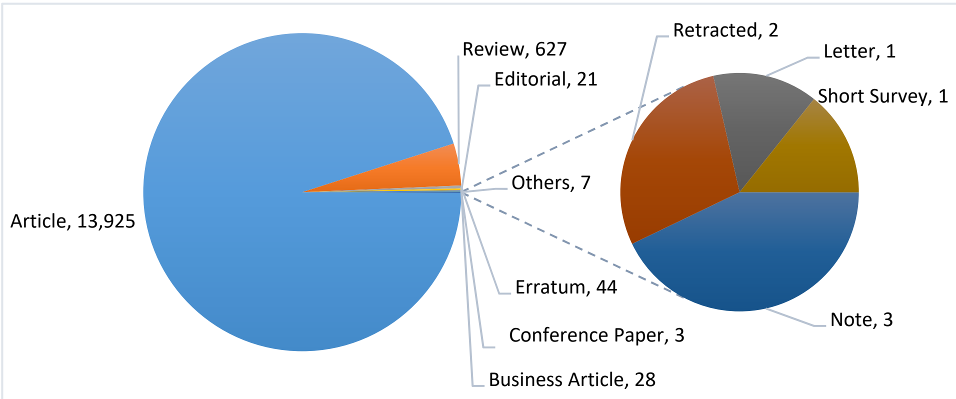


Figure 29. Representation of the type of documents published in Scopus in MDPI's *Energies* journal.

4. Conclusions

This research has considered the publications in MDPI's *Energies* journal in all of its subject areas from 2008 to 2019. Hence, it highlights the most relevant topics published in MDPI's *Energies* journal as a representative journal of the category of energy and fuels. The analysis of the publications shows the temporal evolution of the scientific community's concerns and how they have evolved over the 12 years since the journal was established. After establishing the criteria for keyword searching, 13,370 documents were obtained. By using bibliometric techniques, 9865 documents with 19,835 relations were selected as the core set. These publications were published in different sub-areas which are associated with 14 research communities or research clusters. The smart grid community has the highest concentration of documents (16.74%), followed by the climate change–electric energy community (12.62%), the energy storage one (12.24%), and the bioenergy sources one (10.51%). The other communities that make up less than 10% of manuscripts are: prediction algorithms applied to power (8.82%), optimization of the grid link for renewable energy (8.65%), wind power (5.66%), sustainability of power systems (5.47%), hydrocarbon improvements (4.46%), conversion of thermal/electrical energy (4.24%), electric motor advancements (3.43%), marine renewable energy (2.90%), hydropower and energy storage (2.32%), and preventive techniques in power transformers (1.96%). It is observed that the spatial distribution of the communities presents a concentration in several regions, one of which forms communities with greater contributions, except for hydrocarbon improvements and bioenergy source, which is outside the main core. When a cluster is relatively isolated from the core of the items, it means that it is already a mature technology. This core extends with collaborative links to the rest of the communities. Another more external region forms bioenergy sources, optimization of the grid link for renewable energy, wind power, electric motor advancements, marine renewable energy, and preventive techniques in power transformers. Finally, there is a group of communities that are intertwined with the larger communities, including sustainability of power systems, hydrocarbon improvements, conversion of thermal/electrical energy and hydropower, and energy storage. The smaller clusters are still research areas that are in the process of development, and if they are placed between two larger areas it means that they are taking on identities of their own.

The main keywords are electric vehicle, renewable energy, microgrid, smart grid, and energy efficiency. All of them are highly relevant to the main energy field's concerns. Of the 20 most repeated, only two have contributed to all communities—optimization (195 repetitions) and artificial neural network (107 repetitions). The first one has different meanings in its use, since authors apply it to indicate the optimization of a complete system by improving some part of it or refer to software, used to optimize some system in an automated way or to improve the efficiency. The keyword artificial neural network refers to automatic optimization methods or software decision making.

There are 27,863 authors researching in different topics of MDPI's *Energies* journal in 14 by subject in 118 countries, with China (10,171 researchers) being the largest contributor to MDPI's *Energies* journal, followed by South Korea (1913 researchers) and the United States (1617 researchers). The 20 authors with the highest H-index do not belong to the leading countries of publication. The highest H-index author is from South Korea (H-index 136), the second from Japan (H-index 121), and the third from Denmark (H-index 114), although there are three Chinese, two Korean, and five USA authors among this top 20. MDPI's *Energies* journal promotes publication in nine thematic areas with different topics; however, our research has found 14 themes, which are the communities or clusters described above. The temporal evolution of the documents published in Scopus shows a continuous growth from 2008 to 2020, with 17 sections distributed in 749 Special Issues and 6666 documents published until February 2020. The articles and their citations have an exponential distribution over the years; this is due to the good policy of the topics in their Special Issues, which are very much in line with technological innovation trends. Then, the policy of the Special Issues allows one to be more flexible regarding the rigid topics of a more traditional journal.

The main conclusion is that the research in the journal's themes is not finished; many contributions are still needed to solve the future challenge of providing solutions to the growing demand for energy in environmentally friendly ways. Smart grid, climate change, electric energy, and energy storage are the most relevant ongoing topics. These subjects still need to address many technical, economic, and environmental considerations for the near future. Innovations in electric vehicle charging/discharging and storage systems will lead to major publications in a near future. There is a need to promote industry and consumer thinking, and for greater investments from governments to promote renewable technologies. The research for sustainable and economically efficient energy resources is not yet closed, there are still many contributions to be made. Nowadays, society and the scientific community are more concerned with clean energies to provide short and long-term solutions to the greenhouse effect and gas emissions. This concern is motivated by two considerations, oil shortage and environmental considerations.

Researchers investigating the optimization of energy systems still have major challenges to meet. To meet all these challenges, the collaboration of the entire research community is required. With their contributions, they increase the knowledge in this field, which is so essential for our modern society. In summary, this study will open new perspectives and opportunities for energy-related research.

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