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Figure 11. Table 5. With less importance would be the Central European clusters (in the color Turquoise), Scandinavia-Russia (in the paper. 2018, 253, 304-314. 2018, 35, 50-60. VOSviewer's algorithm aims at locating the items in a lowdimensional space so that the distance between two items is an accurate indicator of their relatedness. Figure 10 shows the detection of scientific communities of authors using the VOSviewer software. [Google Scholar] [CrossRef]Basu, P.; Butler, J.; Leon, M.A. Biomass co-firing options on the emission reduction and electricity generation costs in coalfired power plants. It includes the lines that the USA Environmental Protection Agency (EPA) announced in September 2013, aiminged to reduce emissions by 30% by 2030. [16]. Renewable energy for heating comes either from decentralized equipment in buildings or from centralized generation and its further distribution [17]. [Google Scholar] [CrossRef]Pousa, G.P.; Santos, A.L.; Suarez, P.A. History and policy of biodiesel in Brazil. Figure 13. To this end, the protocol contains targets for industrialized countries to reduce emissions greenhouse gases. Currently, the trend in the growth of these keywords continues due to the sustainability policies carried out by governments and supported by the fight against climate change, which has become a global issue of interest. Figure 13 shows a network map of the co-occurrence of the main keywords used by authors of publications in the last ten years. Mango stone properties as biofuel and its potential for reducing CO2 emissions. Biomass is a resource that is present in a variety of different materials: wood, sawdust, straw, seed waste, manure, paper waste, household waste, wastewater, etc. As can be seen, 6 communities or clusters were found. 2018, 651, 601-613. Identifying communities or clusters is a topic of great current scientific interest, making it possible to identify and to quantify the existing relations of collaboration between the authors of diverse institutions and areas of knowledge. 2018, 190, 53-62. The two most important were focused on obtaining liquid fuels from biomass. Finally, from the collaboration between countries and biomass research, eight clusters were observed. Vosviewer is free software that allows you to build and visualize bibliometric networks from data obtained from bibliometric searches of important databases such as Scopus [36]. However, large amounts of thermal energy are wasted in power generation and in many manufacturing processes. Energy Convers. 2017, 156, 624-634. In addition, in the gaseous state, there is biogas (methane, hydrogen and nitrogen, above all), normally obtained either by anaerobic fermentation of microbiological origin, or by gasification (partial oxidation of biomass at high temperature, about 1400 °C, without combustion) [43]. Biomass generates continuous employment such as the extraction of raw materials from the countryside and the bush [14]. Since journals that publish more articles are more likely to be cited, the so-called journal impact factor was introduced, which normalizes the number of citations according to the size of the journal. The 11 main journals that have published in the search field performed with the Scopus database are shown in Table 5. First place goes to the journal "Renewable and Sustainable Energy Reviews" with an H-Index of 193 and a JCR impact factor of 3.358, and third place goes to "Bioresource Technology" with an H-Index of 229 and a JCR impact factor of 5.807. Figure 8 shows that the highest percentage of documents were in the area of Energy (23.4%), followed by Environmental sciences (18.0%) and Engineering (12.4%). Microbiol. Figure 3 shows the percentage of the different languages in which the different documents obtained from the bibliometric analysis have been published. Figure 4 shows the trend in scientific production over the last 40 years. Figure 12. Table 2. Colors represent the division between keywords according to the field in which they have been used, the size of the circles shows how often a term has been used, and the lines connecting the different circles indicate the link between keywords according to the field in which they have been used, and the lines connecting the different circles indicate the link between keywords according to the field in which they have been used, and the lines connecting the different circles indicate the link between keywords according to the field in which they have been used, and the lines connecting the different circles indicate the link between keywords according to the circles and other publications. [Google Scholar] [CrossRef]Chen, L.; Xing, L.; Han, L. The two most important are focused on obtaining liquid fuels from biomass. District heating and cooling optimization and enhancement—towards integration of renewables, storage and smart grid. The VOS algorithm mapping technique implemented in the software VOSviewer was used to obtain Figure 13. The red cluster is the most important, and is led by the UK; as can be seen, it is composed of its traditional area of political and economic influence, to which Japan joins. Energies 2018, 11, 577. Cluster 6, turquoise in color, revolves around pyrolysis and India as a leading country [58]. From this bibliometric analysis it can be concluded that the main countries that investigate the subject of biomass as renewable energy, as measured by its scientific production, are the United States, followed by China, India, Germany and Italy. Forecasting models suggest that developing countries will account for 99 per cent of this population increase, with population growth of 50 per cent in urban areas [2,3]. Figure 11. This research received no external funding. The authors declare no conflict of interest. Desai, B.G. CO2 emissions—Drivers across time and countries. 2017, 72, 281-294. 2017. This situation in which the percentage of the global energy used in cities is increasing considerably. Evolution of the main authors' publications over the last ten years. Cloud word of main keywords related to biomass as renewable energy. Res. Finally, based on the collaboration between countries and biomass research, eight clusters were observed. This study also identifies communities based on the keywords of the publications obtained from a bibliographic search. Figure 1. World scientific production in biomass as renewable energy by country of origin. 2019, 213, 104–113. The detection of communities has been successfully applied in fields such as medicine [38], or energy [39]. Main thematic areas according to the number of publications obtained. This researcher has an h-index of 15, followed by Pari, L. Energies 2018, 11, 2067. 2007, 141, 301–304. (Italy)TOTAL20085210902620098313100342010100570222011112125232201251141194020139437917762014117185546201512112912462016214010164220171626101819892018922192364TOTAL9892122102103517 Table 7. Decentralized optimization of coordinated electrical and thermal generations in hierarchical integrated energy systems considering competitive individuals. Sustain. Finally, we find clusters 5 and 6, which are the smaller ones. [Google Scholar] [CrossRef] [PubMed] Garrido-Cardenas, J.A.; Manzano-Agugliaro, F.; Acien-Fernandez, F.G.; Molina-Grima, E. Figure 5. [Google Scholar] [CrossRef] [Li, Y.; Rezgui, Y.; Zhu, H. Sustainability 2018, 10, 1515. From this study, the existence of different versions for a keyword can be observed, depending on the way each author expresses himself or herself. Energy 2007, 32, 750–757. Energies 2018, 11, 2382. [Google Scholar] [CrossRef] [Cros straw, seed waste, manure, paper waste, household waste, wastewater, etc. Country communities detected in the topic biomass as renewable energy. C J. Appl. [Google Scholar] [CrossRef]Li, G.; Liu, C.; Yu, Z.; Rao, M.; Zhong, Y.; Jiang, T. Industry consumes all the heat and electricity it needs, and the excess electricity is fed into the grid and is consumed mostly in the local environment [20,21]. [Google Scholar] [CrossRef] Demirbas, M.F.; Balat, M.; Balat, H. The Scopus database was used to search for information using the following search fields: (TITLE-ABS-KEY (biomass) AND TITLE-ABS-KEY (renewable AND energy)). Eng. [Google Scholar] [CrossRef] [PubMed] Rather, M.A.; Khan, and is consumed mostly in the local environment [20,21]. [Google Scholar] [CrossRef] [PubMed] N.S.; Gupta, R. Available online: (accessed on 14 October 2018). Mehedintu, A.; Sterpu, M.; Soava, G. [Google Scholar] [CrossRef] Williams, O.; Taylor, S.; Lester, E.; Kingman, S.; Giddings, D.; Eastwick, C. This figure shows the relationships between the main researchers in the field of biomass as renewable energy. The second most important cluster consists mainly of Latin American countries. Energy Policy 2007, 35, 5393-5398. Indeed, cities represent 70% of the total emissions of CO2 caused by humans [6], being one of the largest contributors to climate change. YearTippayawong, N.(Thailand)Thrän, D.(Germany)Omer, A.M.(United Kingdom)Kaltschmitt, M. Figure 4. [Google Scholar] [CrossRef]Alcayde, A.; Montoya, F.G.; Baños, R.; Perea-Moreno, A.-J.; Manzano-Agugliaro, F. [Google Scholar] [CrossRef]Manzano Agugliaro, F. Potential building stock: A literature review. The main objective of this work was to analyze the state of research and trends in biomass for renewable energy from the last 40 years (from 1978 to 2018) to help the research community understand the future trends, as well as the situation of a country in the international context, all of which provides basic information to facilitate decision-making by those responsible for scientific policy. The analysis of scientific publications constitutes a fundamental step within the research process and has become a tool that allows us to qualify the quality of the process on the environment. Energy 2018, 156, 132-143. It is possible to observe how in 2008 these 5 industrialized countries regain their scientific
production on this subject due to the sustainability policies carried out by the different authors sharing the same publication. The yellow cluster is led by Germany and is mainly related to Eastern European countries. Given the diversity of origins in the production of biogas it is logical to find key words from countries as different in customs such as: Germany, Pakistan and Spain. Software survey: VOSviewer: A computer program for bibliometric mapping. The chips come from the crushing of biomass both agricultural and forest, with their size being variable depending on the manufacturing process from which they are derived, or the transformation process that they have undergone. Its greatest usefulness is obtained when making comparisons with the activity of other institutions, areas or countries, since it is necessary to have a frame of reference within which to locate our object of study. Biores. Figure 2 shows the different types of documents related to biomass as renewable energy during the period 1978-2018. In reference to the type of languages used in the publications obtained from the search, most of the documents were published in English in international journals, followed by Chinese (2.04%), German (0.30%) and Spanish (0.27%). Figure 10. [Google Scholar] [CrossRef] [PubMed] Figure 1. The search result was a .csv file containing the following information: Authors, Author Ids, Title, Year, Source title, Volume, Issue, Art. An introduction to the various technologies and ecological benefits of green walls. Towards forest sustainability in Mediterranean Countries using biomass as fuel for heating. Sustainability 2017, 9, 1294. 2018, 35, 168-185. Bibliometrics is a discipline of scientometrics and provides information on the results of the research process, its volume, evolution, visibility and structure. Figure 6. Nature 2018, 555, 23-25. Table 3. Fuel 2015, 142, 199-207. It follows that large countries in numbers of inhabitants are interested in the use of new renewable energy sources such as the use of biomass. In reference to the main institutions researching biomass as renewable Energy Laboratory, USDA Agricultural Research Service, Washington DC, OAK Ridge National Laboratory), two from China (Chinese Academy of Sciences, Ministry of Education China), one from Denmark (Danmarks Tekniske Universitet), one from Brazil (Universidade de Sao Paulo—USP), one from England (Imperial College London). The red cluster is mainly focused on the production of biodiesel, both in the classic ways of obtaining by transesterification of oils from seeds (especially rapeseed and sunflower) or from vegetable oil residue of industrial processes. Table 7 shows the 40 most significant keywords in the last four decades. As a preliminary step to carrying out searches, you must know, for example, prominent authors in the subject matter of the search, keywords related to the subject, type of publications dedicated to that subject and institutions, events in which the subject and institutions, books, journals, proceedings, etc. Worldwide Research on Energy Efficiency and Sustainability in Public Buildings. [Google Scholar] [CrossRef]Perea-Moreno, A.-J.; Perea-Moreno, M.-A.; Dorado, M.P.; Manzano-Agugliaro, F. 2009, 50, 1746-1760. Low-Carbon Technol. that may be of interest. All this is centered around three countries, belonging to different clusters: USA, India, and the UK. All authors have read and approved the final manuscript. The most productive institutions in this field are the Chinese Academy of Sciences, followed by the National Renewable Energy Laboratory, Danmarks Tekniske Universitet and the Ministry of Education in China. It can be observed that in 2008 the use of these keywords exhibited a great increase, possibly due to the entry into force of the Kyoto Protocol in 2008. The top high-yield authors formed their own cooperative team. The Identification of Scientific Communities and Their Approach to Worldwide Malaria Research. It contains information relating to more than 35,000 titles from all areas. Fruit stones and seeds, as well as fruit husks, though used to a lesser extent than other standardized fuels such as fuelwood, wood chips and pellets, also represent an increasingly used solid biofuel. Approximately 70% of cities are already coping with the effects of climate change. Figure 7. [Google Scholar]Mata-Sánchez, J.; Pérez-Jiménez, J.A.; Díaz-Villanueva, M.J.; Serrano, A.; Núñez-Sánchez, N.; López-Giménez, F.J. Statistical evaluation of quality parameters of olive stone to predict its heating value. Interciencia 2007, 32, 131-136. Pyrolysis and kinetic analyses of a perennial grass (Saccharum ravannae L.) from north-east India: Optimization through response surface methodology and product characterization. Renewable energy from agro-residues in China: Solid biofuels and biomass briquetting technology. Since 90% of all urban areas are coastal, the damage caused by rising sea levels is expected to increase, with some cities in developing countries being particularly vulnerable. Potential of biomass district heating systems in rural areas. Scientific communities are usually groups that relate to members of groups from other communities [37]. Figure 9 and Table 6 show the scientific production of the 4 main authors on this subject in the last ten years. Technol. 2016, 135, 1233-1241. [Google Scholar] [CrossRef]Montoya, F.G.; Alcayde, A.; Baños, R.; Manzano-Agugliaro, F. Biomass refers to all organic matter existing in the biosphere, whether of plant or animal origin, as well as those materials obtained through their natural or artificial transformation [8,9,10]. All this is centered on three countries belonging to different clusters: USA, India and the UK. Table 4. Rooftop analysis for solar flat plate collector assessment to achieving sustainability energy. However, it must be borne in mind that direct combustion of biomass is not always feasible in existing facilities, and that in many cases it is necessary to carry out physical-chemical or biological treatments to adapt it to the quality of conventional fuels. Telemat. Table 8 shows the principal characteristics of each cluster detected in Figure 13. Insects for biodiesel production. Fuel 2016, 186, 358-364. Another key aspect of this research was the identification of scientific communities using Vosviewer software (. Cogeneration is the most widely used technology to reuse lost heat, generating useful heat as well as electrical energy. Therefore, the main language of publications on this subject are in English (95.3%), followed by Chinese (1.4%). [Google Scholar] [CrossRef]Weiland, P. The third cluster is devoted to two fundamental issues, the generation of electricity from biomass and the production of biogas, the latter produced from livestock waste [52], arban solid waste [53], agricultural waste [54] and industrial organic waste [55]. Figure 9. Among its great benefits is the forest use of the territory, which would also serve to clean the forest and thus prevent forest fires, and the ability to generate jobs. Renew. Main researches on biomass as biofuel during the last ten years. The VOS algorithm mapping technique implemented in the software VOSviewer [40] was used to identify and to quantify the collaboration between authors. Pellets are used especially in fuels with a low energy/volume ratio [11,12]. Bioresour. The increase in urban energy consumption has also led to an increase in urban e are significant annual volumes of agricultural production, whose by-products can be used as a source of energy and are even being promoted as so-called energy crops, specifically for this purpose. [Google Scholar] [CrossRef]Rasi, S.; Veijanen, A.; Rintala, J. Biomass is present in a variety of different materials: wood, sawdust, straw, seed waste manure, paper waste, household waste, wastewater, etc. Subject AreaNumber of PublicationsEnergy7714Environmental Sciences3297Chemistry1625Biochemistry, Genetics and Molecular Biology1288Materials Science803Earth and Planetary Sciences791Immunology and Microbiology689Social Sciences675Physics and
Astronomy627Computer Science502Business, Management and Accounting452Mathematics314Economics, Econometrics and Finance296Medicine181Multidisciplinary167Decision Sciences83Pharmacology, Toxicology and Pharmaceutics70Others74 Table 5. Figure 7 Trend in biomass as renewable energy publications during the period 1978-2018. Biomass Bioenergy 2019, 120, 324-331. This includes new sources of fat or raw materials such as microalgae [44,45] or insects [46], and was found as a keyword for the country of Brazil [47,48]. Available online: (accessed on 13 October 2018). Perea-Moreno, A.-J.; Aguilera-Ureña, M.-J.; Manzano-Agugliaro, F. J. Methodology scheme. Analysis of Research Topics and Scientific Collaborations, to gray, which indicates the non-existence of publications. [Google Scholar] [CrossRef]Miranda, M.T.; Sepúlveda, F.J.; Arranz, J.I.; Montero, I.; Rojas, C.V. Analysis of pelletizing from corn cob waste. 2018, 13, 380-387. 2005, 86, 1351-1368. Collaborative work between countries. Figure 2. Co-digestion of microalgae and primary sludge: Effect on biogas production and microcontaminants removal. 2002, 114, 46-53. Figure 10. Mater. Evaluation of the performance of hybrid CSP/ biomass power plants. Asian research connections between them stand out due to both the language and the proximity of their institutes. As for the area in which the different research connections between them stand out due to both the language and the proximity of their institutes. As for the area in which the different research connections between them stand out due to both the language and the proximity of their institutes. biomass is published, the area of Energy stands out (23.4%); this is because most of the research is directed at the use of biomass to produce thermal energy or electrical energy. This study has also identified communities based on the keywords of the publications and collaboration between countries obtained from the bibliographic search. Fuel Process. Trends Biotechnol. It should be noted that the keyword most used by most of these institutions is Biofuel, ranking first in five of the ten institutions. Int. In solid state are basically wood and chips, charcoal and pellets [42]. 2017, 20, 168-174. For example, it was analyzed who the main authors were that have published on this subject, or what types of documents have been published on this subject (articles, reviews, etc.). Community detection. Thematic areas of publications obtained from the Scopus search. Decentralized biomass boilers are an emerging technology in constant development [18]. A comprehensive city-level GHGs inventory accounting quantitative estimation with an empirical case of Baoding. [Google Scholar] [CrossRef]Perea-Moreno, M.A.; Manzano-Agugliaro, F.; Hernandez-Escobedo, Q.; Perea-Moreno, A.J. Peanut Shell for Energy: Properties and Its Potential to Respect the Environment. A fast method for identifying worldwide scientific collaborations using the Scopus database. [Google Scholar] [CrossRef]Bergmann, J.C.; Tupinambá, D.D.; Costa, O.Y.A.; Almeida, J.R.M.; Barreto, C.C.; Quirino, B.F. Biodiesel production in Brazil and alternative biomass feedstocks. Green Build. Energy Rev. 2017, 74, 349-363. 2013, 21, 411-420. [Google Scholar] [CrossRef]Solé-Bundó, M.; Garfí, M.; Matamoros, V.; Ferrer, I. One of the main characteristics of biomass that makes it suitable as an energy source is that through direct combustion it can be burned in waste conversion plants to produce electricity [23] or in boilers to produce electricity in urban areas during the last 18 years for the top five countries. Energy 2007, 32, 1375-1380. 2010, 85, 849-860. During the last 40 years, 17,254 documents have been found, among which the keyword Biomass, appearing in 9753 items, stands out, followed by Renewable Energy (2511 items). Areas such as Earth and Planetary Sciences (2.4%), Materials Science (2.4%) or Immunology and Microbiology (2.1%) were found to a lesser extent. Biofuels derived from biomass include firewood, wood shavings, pellets, some fruit stones such as olives and avocados, as well as nutshells. [Google Scholar] [CrossRef] [PubMed]Montoya, F.G.; Baños, R.; Alcayde, A.; Montoya, M.G.; Manzano-Agugliaro, F. Scientific production and keywords used by the ten most important international institutions. [Google Scholar] [CrossRef] [PubMed]Bai, X.; Dawson, R.J.; Ürge-Vorsatz, D.; Delgado, G.C.; Barau, A.S.; Dhakal, S.; Roberts, D. Distribution of different types of publications during the period 1978-2018. [Google Scholar] Scholar] [CrossRef]International Renewable Energy Agency (IRENA). According to the different types of publications, most of the research works were Articles (59.0%), followed by Conference Papers (23.2%) and Reviews (9.4%). Are green walls as "green" as they look? [Google Scholar] [CrossRef]Lu, C.; Li, W. Table 7. 2009, 4, 1-18. According to the World Health Organization (WHO), 90% of the inhabitants of urban areas are subject to environmental pollution levels that exceed the recommended limits [7]. [Google Scholar] [CrossRef]Heredia Salgado, M.A.; Rivadeneira, D.; Narváez C, R.A. Palm oil kernel shell as solid fuel for the commercial and industrial sector in Ecuador: Tax incentive impact and performance of a prototype burner. Therefore, the reason was the high price of oil followed by a widespread economic downturn. Figure 5 shows world scientific production by country of origin. 2008, 26, 126–131. Table 1 presents a synthesis of the ways of approach from the literature depending of the type of biomass. At present, a large part of the research has been focused on environmentally friendly and sustainable energy in industrialized countries is a key element in achieving sustainable energy from biomass to supplement conventional fossil fuels [33]. Algal Res. Table 8. From this, it can be concluded that the use of biomass as renewable energy in industrialized countries is a key element in achieving sustainable energy from biomass as renewable energy in industrialized countries is a key element in achieving sustainable energy from biomass as renewable energy from biomass and the energy from biomass and the energy development. Curr. Materials 2018, 11, 1329. [Google Scholar] [CrossRef]Kılkış, Ş.; Krajačić, G.; Duić, N.; Rosen, M.A.; Al-Nimr, M.A. Advancements in sustainable development of energy, water and environment systems. From the collaboration between countries and biomass research, eight clusters are observed, see Figure 7 and Table 2. [Google Scholar] [CrossRef]Shah, M.A.; Khan, M.N.S.; Kumar, V. Figure 3. with an h-index of 17 and Tippayawong, N. [Google Scholar] [CrossRef]Garrido-Cardenas, J.A.; Manzano-Agugliaro, F.; Alcayde-Garcia, A.; Novas, N.; Mesa-Valle, C. Combined Heat and Power plants (CHP) simultaneously produce electricity and heat for use in industrial, trade or residential contexts. Calorim. The other line of work in this cluster is the production of hydrogen or other hydrocarbons from biomass gasification [23]. [Google Scholar]Perea-Moreno, M.A.; Manzano-Agugliaro, F.; Perea-Moreno, A.J. Sustainable energy based on sunflower seed husk boiler for residential buildings. In addition, cities face devastating effects from climate change. Figure 8. Fuel properties of avocado stone. In Figure 11, a cloud of words is shown where the size of the letters represents the importance of the keyword according to the number of items in which it appears. Figure 12 shows the evolution over time of the 5 keywords that appear in the largest number of publications related to the use of biomass as renewable energy. Environ. With respect to the type of research carried out, it can be seen how Chinese institutions focus on liquid fuels such as ethanol and how it is obtained from crops, especially corn (Zea Mays) in the USA and sugarcane in Brazil. 2019, 660, 974-981. InstitutionCountryDocumentsMain Keywords Used123Chinese Academy of SciencesChina267Biological MaterialsGasificationCarbonNational Renewable Energy LaboratoryUSA180BiofuelEthanolCelluloseDanmarks Tekniske UniversitetDenmark136Carbon DioxideEthanolBiofuelMinistry of Education ChinaChina116CarbonBiofuelBiological MaterialsUniversidade de Sao Paulo—USPBrazil112Ethanol BiofuelBioenergyLigninWageningen University and Research CentreNetherlands104BioenergyBiological MaterialsNonhumanSveriges LanbruksuniversitetSweden97ForestryBioenergyFuelsImperial College LondonEngland84BioenergyFuelsImperial College LondonEngland84Bioe characterization for their potential application as biofuels. The Higher Education Sustainability through Virtual Laboratories: The Spanish University as Case of Study. The world's population continues to grow at a high rate, such that today's population is twice that of 1960, and it is projected to increase further to 9 billion by 2050 [1]. In 2008 there is a very important growth due to energy policies to encourage the use of renewable energy due to the increase in the price of a barrel of oil. Evolution of the top five keywords in the period 2001-2018. Departamento de Física Aplicada, Universidad de Córdoba, CEIA3, Campus de Rabanales, 14071 Córdoba, Spain Faculty of Law, Universidad Internacional de La Rioia (UNIR). Av. de la Paz. 137, 26006 Logroño. Spain Author to whom correspondence should be addressed. This study also carried out an analysis of the most prominent authors in the fields of renewable energy production with biomass. The main objective of this work was to analyze the state of research and trends in biomass. for renewable energy from 1978 to 2018 to help the research community understand the current situation and future trends, as well as the situation of countries in the international context, all of which provides basic information to facilitate decision-making by those responsible for scientific policy. Six communities or clusters were found. In liquid form, bioethanol and biodiesel stand out. Sustainability 2019, 11(3), 863; Received: 24 December 2018 / Revised: 3
February 2019 / Accepted: 4 February 2019 / Accepted: 4 February 2019 / Published: 7 February 2019 / Pub 2050. Within industrialized countries, governments promote energy policies with the aim of reducing greenhouse gases and consequently global warming. In the United States, a climate change plan called the 'Clean Power Plan' stands out. The characteristics of some materials allow them to be used as fuels directly; however, others require a series of pretreatments, which require different technologies before they can be used. Biomass has its flaws, but also its strengths. Biogas production by anaerobic co-digestion of cattle slurry and cheese whey. To avoid this problem, an alternative method was introduced for the counting of citations received by papers, consisting of attributing a weight to publication journals based on the average number of citations received by their papers. 2013, 148, 196-201. Sustainability 2018, 10, 3254. It can therefore be deduced that there are two forms of grouping: the first is based on the influence or economic relations between groups of countries, which in this scenario would be the four most important clusters; and the second would be in terms of the type of biomass they may have, based on their geographical location or climatic conditions, which in this situation would be the last three clusters. Table 3 shows the ten institutions with the highest scientific production in the field of biomass as renewable energy, as well as the keywords most used by these institutions. In the first place, the Chinese Academy of Sciences, with 180, Danmarks Tekniske Universitet with 136, Ministry of Education China with 116, University of Sao Paulo with 112, USDA Agricultural Research Service, Washington DC with 108, OAK Ridge National Laboratory with 107, Wageningen University and Research Centre with 104, Sveriges Lanbruksuniversitet with 97 and Imperial College London with 84, Sci. ClusterColorCountriesGeographic Areas%1RedAustralia-Bangladesh-Brunei Darussalam-Indonesia-Japan-Malaysia-Pakistan-Philippines-Saudi Arabia-Singapore-South Korea-Taiwan-Thailand-United Arab Emirates-United KingdomAsia-Portugal-Spain and Portugal14.753BlueCanada-China-Iran-Mexico-Darussalam-Indonesia-Japan-Malaysia-Pakistan-Philippines-Saudi Arabia-Singapore-South Korea-Taiwan-Thailand-United Arab Emirates-United KingdomAsia-Pakistan-Philippines-Saudi Arabia-Singapore-South Korea-Taiwan-Thailand-United Arab Emirates-United Arab Emirates-United KingdomAsia-Pakistan-Philippines-Saudi Arabia-Singapore-South Korea-Taiwan-Thailand-United Arab Emirates-United Arab E New Zealand-Switzerland-Turkey-United StatesNorth America-China13.114YellowAlgeria-Germany-Italy Latvia-Lithuania-Poland-Slovakia-UkraineEastern Europe-Germany13.115PurpleHungary-India-Ireland-Israel-Romania-Viet NamIndia11.486TurquoiseAustria-Croatia-Denmark-Norway-Serbia-SloveniaCentral Europe9.847GreyBelgium-Finland-Israel-Romania-Viet NamIndia11.486TurquoiseAustria-Central Europe9.847GreyBelgium-Finland-Israel-Romania-Viet NamIndia11.486TurquoiseAustria-Viet NamIndia11.486TurquoiseAustria-Viet NamIndia11.486TurquoiseAustria-Viet NamIndia11.486Turqu France-Russian Federation-SwedenScandinavia-Russia 8.208OrangeEgypt-Nigeria-South AfricaAfrica4.92 Table 3. The green cluster is the second most important and consists mainly of Latin American countries. This situation in which the percentage of global energy used in cities is increasing considerably. All this is centralized around three countries belonging to different clusters: USA, India, and the UK. For example, looking at Table 6, similar concepts can be observed written in different ways, such as: 'Renewable Energy', 'Renewable E publish more items related to biomass as renewable energy are: "Renewable energy Reviews", "Biomass and Bioenergy" and "Bioresource Technology". One of the growing interest in research in the field of biomass as renewable energy. As can be seen, during the first 30 years there is no significant growth in scientific production on the use of biomass as renewable energy. [Google Scholar] [CrossRef]Wang, L.; Jing, Z.X.; Zheng, J.H.; Wu, Q.H.; Wu, Q. scientific community. [Google Scholar] [CrossRef]Lee, Y.; Park, J.; Ryu, C.; Gang, K.S.; Yang, W.; Park, Y.K.; Jung, J.; Hyun, S. Production of solid biofuel from macrophyte Potamogeton lucens. Power Quality: Scientific Collaboration Networks and Research Trends. with an h-index of 15.A scientific community can be defined as a set of nodes that are more densely connected to each other than to the rest of the network. Renewable Energy in Urban Areas: Worldwide Research Trends. Table 6. Comparison of biochar properties from biomass residues produced by slow pyrolysis at 500 C. Table 1. [Google Scholar] [CrossRef]González, J.F.; González-García, C.M.; Ramiro, A.; Gañán, J.; González, J.; Sabio, E.; Román, S.; Turegano, J. Finally, pellets are the most elaborate biofuel, and consist of small cylinders 6 to 12 mm in diameter and 10 to 30 mm in length that are obtained by pressing biofuels with binders. Carbon Res. The purple cluster 5 focuses on the Power Plant and the alternative to the Coal, as it has topics related to environmental impact [57]. It includes, in addition to journals, monographic series, conference proceedings, books (emptied at book and chapter level) and patents. Figure 9. 2018, 115, 386-387. The second cluster, the green one, is more focused on bioethanol, produced either from sugars from crops such as sugar cane [49] or beet [50], or from starches from crops such as potatoes, corn or other cereals. 2016. YearBiomass TypeReference2018Walnut shellAgriculture residueUltimate analysis[17]2018Peanut shellIndustrial residueUltimate analysis[17]2018Mango stoneIndustrial residueUltimate analysis[17]2018Walnut shellAgriculture residueUltimate analysis[18]2018Walnut shellA residueUltimate analysis[13]2016Avocado StoneIndustrial residueUltimate analysis[29]2015Pine pelletsForestsUltimate analysis[29]2018Sun flower seed huskIndustrial residueUltimate analysis[24]2015Pine pelletsForestsUltimate analysis[30]2019Palm oil Kernel ShellIndustrial residueProximate analysis[31]2018Corn cob wasteIndustrial residueUltimate analysis[32] Table 2. The main countries that are investigating the subject of biomass as a renewable energy, as measured by scientific production, are the United States, followed by China, India, Germany and Italy. Therefore, the analysis of keywords in scientific publications is of great importance to knowing the research trends and their follow-up. No., Page end, Page e N.; Kataki, R. Figure 3. [Google Scholar] [CrossRef]Muresan, A.A.; Attia, S. The community detection of thematic clusters (community or cluster detection) was analyzed with VOSviewer, obtaining maps of international collaboration between different countries and authors, and the research trends using keywords. The number of publications of an institution, area or country is a useful indicator to quantify the scientific activity of these units. [Google Scholar] [CrossRef]Elango, D.; Pulikesi, M.; Baskaralingam, P.; Ramamurthi, V.; Sivanesan, S. Figure 12. Scientific communities tend to have a central nucleus cohesive with peripheral spheres, which are the weakest links as it moves away from the nucleus. JournalsQSJRH-IndexJCRTotal Docs (2 Years)Total Cites (3 Years)Total Cites (3 Years)CountryRenewable and Sustainable Energy ReviewsQ13.0361939.18414393,330152,27634,86910.03The NetherlandsBiomass and BioenergyQ11.2351463.358257112611,10044063.59United KingdomBioresource TechnologyQ12.0292295.8071638464465,02329,0416.15The NetherlandsRenewable EnergyQ11.8471434.9001039267938,95814,2695.40United KingdomEnergyQ11.9901464.9681951429086,12323,8964.80United KingdomEnergyPolicyQ11.9941594.039713163638,57580864.27United KingdomApplied EnergyQ13.1621407.9001,775411287,10334,5418.30United KingdomEnergy Procedia-0.52456-5305754682,54210,7721.32United KingdomInternational Journal of Cleaner ProductionQ11.4671325.6512,574124143,51123,5835.34The NetherlandsEnergy Conversion and ManagementQ12.5371476.3771079312349,90021,2866.84United Kingdom Table 6. [Google Scholar] [CrossRef]de la Cruz-Lovera, C.; Perea-Moreno, A.-J.; de la Cruz-Fernández, J.-L.; Alvarez-Bermejo, J.A.; Manzano-Agugliaro, F. Biodiesel from microalgae beats bioethanol. Omer, A.M. stands out in this field with 122 publications since 2008. Energy saving of composite agglomeration process (CAP) by optimized distribution of pelletized feed. Sustainability 2018, 10, 4510. 2017, 148, 545-554. and A.-J.P.-M. Use of almond residues for domestic heating: Study of the combustion parameters in a mural boiler. Figure 1 shows a scheme of the methodology used. The methodology used in this study contained the following steps:Global search for information. Production of biogas from municipal solid waste with domestic sewage. Figure 2. 2018, 176, 164-183. [Google Scholar] [CrossRef]Arranz, J.I.; Miranda, M.T.; Montero, I.; Sepúlveda, F.J.; Rojas, C.V. Characterization and combustion behaviour of commercial and experimental wood pellets in south west Europe. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (. 2018, 228, 303-311. In this way, it is possible to assess scientific activity and the impact of both research and sources [34]. Bibliometric studies provide an interesting overview of a country's own scientific activity, as well as its situation in the international context, all of which provides basic information to facilitate decision-making by those responsible for scientific policy. In this study, a complete search of Elsevier's Scopus database was conducted using the subfields (TITLE-ABS-KEY (biomass) AND TITLE-ABS-KEY (renewable country) and the subfields (the subfields of the subfields) and the subfields (the subfields) are subfields (the subfields). AND energy)) to identify publications addressing the subject of publications
from 1978 to 2018 that referred to biomass as renewable energy. Scopus is a bibliographic database of documents from scientific journals. [Google Scholar] [CrossRef]Perea-Moreno, M.-A.; Hernandez-Escobedo, Q.; Manzano-Agugliaro, F. Language of publications for the period 1978-2018. Fuel 2013, 113, 750-756. Clustering scientific publications is an important problem in current research. The United States is the country with the highest number of publications (3318) in this field, followed by China (1514), India (1165), Germany (1137) and Italy (993). Figure 13. Distributed energy systems consist of a network of underground insulated pipes, connected to a thermal or cold heat plant, through which hot or cold water is pumped to several buildings within a district [14]. Due to the wide availability of biomass worldwide, mainly because it can be obtained as a by-product of many industrial and agricultural processes, biomass represents a growing renewable energy source with high growth potential [22]. [25]. [Google Scholar] [CrossRef]Perea-Moreno, A.-J.; García-Cruz, A.; Novas, N.; Manzano-Agugliaro, F. [Google Scholar] [CrossRef]Perea-Moreno, A.-J.; García-Cruz, A.; Novas, N.; Manzano-Agugliaro, F. [Google Scholar] [CrossRef]Perea-Moreno, A.-J.; García-Cruz, A.; Novas, N.; Manzano-Agugliaro, F. [Google Scholar] [CrossRef]Perea-Moreno, A.-J.; García-Cruz, A.; Novas, N.; Manzano-Agugliaro, F. [Google Scholar] [CrossRef]Perea-Moreno, A.-J.; García-Cruz, A.; Novas, N.; Manzano-Agugliaro, F. [Google Scholar] [CrossRef]Perea-Moreno, A.-J.; García-Cruz, A.; Novas, N.; Manzano-Agugliaro, F. [Google Scholar] [CrossRef]Perea-Moreno, A.-J.; García-Cruz, A.; Novas, N.; Manzano-Agugliaro, F. [Google Scholar] [CrossRef]Perea-Moreno, A.-J.; García-Cruz, A.; Novas, N.; Manzano-Agugliaro, F. [Google Scholar] [CrossRef]Perea-Moreno, A.-J.; García-Cruz, A.; Novas, N.; Manzano-Agugliaro, F. [Google Scholar] [CrossRef]Perea-Moreno, A.-J.; García-Cruz, A.; Novas, N.; Manzano-Agugliaro, F. [Google Scholar] [CrossRef]Perea-Moreno, A.-J.; García-Cruz, A.; Novas, N.; Manzano-Agugliaro, F. [Google Scholar] [CrossRef]Perea-Moreno, A.-J.; García-Cruz, A.; Novas, N.; Manzano-Agugliaro, F. [Google Scholar] [CrossRef]Perea-Moreno, A.-J.; García-Cruz, A.; Novas, N.; Manzano-Agugliaro, F. [Google Scholar] [CrossRef]Perea-Moreno, A.-J.; García-Cruz, A.; Novas, N.; Manzano-Agugliaro, F. [Google Scholar] [CrossRef]Perea-Moreno, A.-J.; García-Cruz, A.; Novas, N.; Manzano-Agugliaro, F. [Google Scholar] [CrossRef]Perea-Moreno, A.-J.; García-Cruz, A.; Novas, N.; Manzano-Agugliaro, F. [Google Scholar] [CrossRef]Perea-Moreno, A.-J.; García-Cruz, A.; Novas, N.; Manzano-Agugliaro, F. [Google Scholar] [CrossRef]Perea-Moreno, A.-J.; Manzano-Agugliaro, F. [Google Scholar] [CrossRef]Perea-Moreno, A.-J.; Manzano-Agugliaro, F. [Google Scholar] [CrossRef]Perea-Moreno, A. [Google Scholar] [CrossRef]Perea-Moreno, A. [Google Scholar] [CrossRef]Perea-Moreno, A. [Google Scholar] [CrossRef]Perea-More research is that of CO2 emissions (carbon dioxide), where they focus on reducing emissions and energy policy, in this case we have the Danmarks Tekniske Universitet and the Imperial College London. In contrast, the smallest numbers of documents were obtained for Notes (1.2%), Books (0.9%) and Short Surveys (0.6%). It is the main international instrument for tackling climate change. [Google Scholar] [CrossRef]Chisti, Y. Contribution of the wood-processing industry for sustainable power generation: Viability of biomass-fuelled cogeneration in sub-saharan africa. Microalgae research worldwide. Clean Prod. Applicability of mechanical tests for biomass pellet characterisation for bioenergy applications. [Google Scholar] [CrossRef]Salmerón-Manzano, E.; Manzano-Agugliaro, F. This means that the share of the urban population. The central nucleus would be formed by the most significant elements of the community. Estimation and forecasts for the share of renewable energy consumption in final energy consumption by 2020 in the european union. [Google Scholar] [CrossRef]Perea-Moreno, A.J.; Juaidi, A.; Manzano-Agugliaro, F. On the other hand, district heating and cooling networks are a highly effective way to integrate natural resources such as industrial and agricultural biomass, while increasing energy efficiency. The distribution of publications by thematic areas was also obtained from the bibliometric analysis using the Scopus database. Total Environ. Gasification by GIS. Patents are vacated from five official offices (WIPO, EPO, United States, Japan and United Kingdom), offering more than 27 million [35]. Temporal coverage dates back to 1823. In addition to providing bibliographic information, Scopus offers bibliometric tools that measure the performance of publications and authors, based on the count of citations received for each article. Once the results of the Scopus search related to biomass as a renewable energy were obtained, this study carried out an analysis of the types of documents, language of the documents, scientific productions related to the subject, collaborations between countries and main authors in the subject, and the evolution in the use of key words. The most important cluster is led by the UK, and as can be seen, it is composed of its traditional area of political and economic influence, to which Japan is joined. [Google Scholar] [CrossRef]Soltero, V.M.; Chacartegui, R.; Ortiz, C.; Velázquez, R. Figure 8. This figure was extracted from the software VOSviewer v.1.6.6., which uses the information obtained from the Scopus search and which can be downloaded as a .csv file. [Google Scholar] [CrossRef] [PubMed]World Health Organization (WHO). [Google Scholar] [CrossRef] [PubMed] [PubMed Temperature Pyrolysis of Lignocellulosic Biomass. Scientometrics 2010, 84, 523-538. 2018, 134, 2137-2145. OrderTERMItems%1Biomass975317.292Renewable Energy Resources49008.693Renewable Energy Fuels14782.629Bioenergy13532.4010Biological Materials13502.3911Energy Policy12542.2212Sustainable Development12412.2013Gasification11662.0714Renewable Energy Source11081.9615Solar Energy10991.9516Greenhouse Gases10841.9217Ethanol10501.8618Carbon9991.7719Fuels9911.7620Forestry9871.7521Biogas9831.7422Wind Power9451,6823Energy Efficiency9431,6724Biomass Power9101,6125Nonhuman9021,6026Priority Journal8741.5527Environmental Impact8721.5528Combustion8601.5229Energy Utilization8591.5230Alternative Energy8031.4231Cellulose8021.4232Pyrolysis7801.3833Hydrogen7731.3734Gas Emissions7391.3135Agriculture7361.3036Fermentation7191.2737Crops7161.2738Climate Change7151.2740Economics6841.21 Table 8. [Google Scholar] [CrossRef]Cardona, C.A.; Quintero, J.A.; Paz, I.C. Production of bioethanol from sugarcane bagasse: status and perspectives. with an h-index of 14, Kaltschmitt, M. This fact, together with the increasing worldwide production of these by-products, makes them especially attractive for thermal energy generation, as well as to reduce CO2 emissions. Forty main keywords used in publications. 2009, 13, 2689-2695. Although cities continue to use fossil fuels as the main source of energy, energy sustainability is becoming a key political solution to mitigate problems related to climate change [5]. The fourth yellow cluster focuses on China and the assessment of its resources for sustainable development [56]. ClusterColorMain KeywordsTopic%1RedBiodiesel production-microalgae-opportunityoverview-use-woody biomassBiogas-Biodiesel22.642GreenBioethanol production-biomass gasification-carbon-catalyst-hydrogen production-lifuence-investigation-performance-renewable source-syngas-valorizationBioethanol-Hydrogen production-biomass Gasification-performance-renewable source-syngas-valorization-performance-renewable source-syngas-valorization-performance-renewable-performance-renewable-performance-renewable-performance-renewable-performance-renewable-performance-renewable-performance-renewable-performance-renewable-performance-renewable-performance-r Pakistan-SpainBiogas-Electricity generation18.874YellowBiofuel production-China-electricity-impact-renewable energy resource-strategy-sustainable developmentChina13.215PurpleCoal-environmental impact-heat-life cycle assessment-power plant-residual biomassPower Plant-Coal11.326TurquoisePyrolysis-Bio oil-bioenergy production-china-electricity-impact-renewable energy resource-strategy-sustainable developmentChina13.215PurpleCoal-environmental impact-heat-life cycle assessment-power plant-residual biomassPower Plant-Coal11.326TurquoisePyrolysis-Bio oil-bioenergy production-china-electricity-impact-renewable energy resource-strategy-sustainable developmentChina13.215PurpleCoal-environmental impact-heat-life cycle assessment-power plant-residual biomassPower Plant-Coal11.326TurquoisePyrolysis-Bio oil-bioenergy production-china-electricity-impact-renewable energy resource-strategy-sustainable developmentChina13.215PurpleCoal-environmental impact-heat-life cycle assessment-power plant-residual biomassPower plant-residual biomassPo characterization-India-modelling-Pyrolysis 11.32 © 2019 by the authors, [Google Scholar] [CrossRef]Comino, E.; Riggio, V.A.; Rosso, M. Figure 6. 2018, 4, 51. Biogas production: Current state and perspectives. Cluster 1 (red) is the biggest in terms of number of members with ten authors, followed by cluster 2 (green) with eight authors. In 2008 there is a very important growth in publications due to oil peaking at over \$136 a barrel in June 2008, and it has never been that high since then. M.-A.P.-M., E.S.-M. Biomass District Heating (BDH) is a very effective system for the integration of natural energy resources within urban environments, achieving on the one hand a 100% reduction in CO2 emissions compared to fossil fuels, and on the other hand an increase in energy efficiency due to the lower cost of bioques from different biogas production plants. Biomass Bioenergy 2009, 33, 822-827. Main keywords used by the communities detected in the topic biomass as
renewable energy. SJR, H-Index and JCR impact factor of principal international journals. The largest node is Zhang, X., who has 19 publications and 8 neighbors, followed by Wang, Y., who has 19 publications and 8 neighbors, followed by Wang, Y., who has 19 publications and 7 members. Another important analysis to carry out is that of the key words used in the publications related to the topic of study. [Google Scholar] [CrossRef]Soares, J.; Oliveira, A.C.; Dieckmann, S.; Krüger, D.; Orioli, F. Table 4 shows the thematic areas of publications obtained from the Scopus search. The assessment of the impact of papers through the citations obtained from the Scopus search. documents. Anal. This USA Clean Energy Plan set carbon pollution standards for power plants, states and utilities for the first time, with the flexibility that they need to meet their standards. Figure 6 represents the evolution of the number of documents from the 5 countries with the highest scientific production related to biomass as renewable energy (Germany)Pari, L. [Google Scholar] [CrossRef]Dodić, S.; Popov, S.; Dodić, J.; Ranković, J.; Ranković carried out considering various fields and types of documents for the period 1978-2018. Of these, cut and chopped firewood is the least processed, and is usually burned directly in domestic appliances such as stoves and boilers. Licensee MDPI, Basel, Switzerland. The "Others" area includes unspecified subject areas. The objective of the Kyoto Protocol was to reduce global greenhouse gas emissions by 5.2% compared to 1990 levels over the period 2008-2012 [41]. Energy 2011, 36, 282-288. [Google Scholar] [CrossRef] [PubMed] Manzano-Agugliaro, F.; Sanchez-Muros, M.J.; Barroso, F.G.; Martínez-Sánchez, A.; Rojo, S.; Pérez-Bañón, C. [Google Scholar] [CrossRef] [PubMed] Manzano-Agugliaro, F.; Sanchez-Muros, M.J.; Barroso, F.G.; Martínez-Sánchez, A.; Rojo, S.; Pérez-Bañón, C. [Google Scholar] [CrossRef] [PubMed] Manzano-Agugliaro, F.; Sanchez-Muros, M.J.; Barroso, F.G.; Martínez-Sánchez, A.; Rojo, S.; Pérez-Bañón, C. [Google Scholar] [CrossRef] [PubMed] Manzano-Agugliaro, F.; Sanchez-Muros, M.J.; Barroso, F.G.; Martínez-Sánchez, A.; Rojo, S.; Pérez-Bañón, C. [Google Scholar] [CrossRef] [PubMed] [CrossRe Hernandez-Escobedo, Q.; Perea-Moreno, A.-J. Energy 2018, 158, 607-622. Public Health 2018, 15, 2703. Indeed, it has been shown that mango stone, peanut shell and sunflower seed husk have a high energy potential, with a Higher Heating Value (HHV) similar to other commercialized biofuels [13,14,15]. Co-occurrence keywords: clusters. The blue cluster is led by the USA and is in close relationship with China and other North American countries such as Canada and Mexico. As can be seen, during the first 30 years, there is no significant growth in scientific production on the use of biomass', Renewable Energy'. 'Renewable Resource' and 'Renewable Energies' are the most commonly used words, although they are not the ones that are most related to other key words such as 'Carbon' or 'Bioenergy'. Biofuels are used in all three states of matter, i.e., solid, liquid and gaseous. In the early 1990s, cities consumed less than half of the total energy produced, while they currently use two-thirds of the worldwide energy [4]. Biomass is a carbon-neutral energy source, since the biomass during its growth absorbs CO2 that is then released into the atmosphere during its combustion, with a zero-net balance of CO2 emissions [19]. Hazard.

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