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THE GREEN DEAL POLICY FOR RENEWABLE ENERGY: A BIBLIOMETRIC ANALYSIS

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Abstract. The industry attention to the environment has been reducing lately, leading to irreversible climate change, reaching the limit of mining, and critical indicators of CO2 emissions. That is why the EU has launched a new Green Policy which includes strategic directions for energy efficiency and which is expected to restore biodiversity and slow down the pace of climate change. Thus, on December 11, 2019, there was held the presentation of the "European Green Course", the main targets of which are to increase the level of energy saving by creating closed cycles in the economy; to minimize greenhouse gas emissions by 2050; to form biodiversity and climate neutrality. Accordingly, countries that accept the terms of the green deal policy need to review all aspects of their economy, from energy production to food consumption, from industry to transport and construction. The purpose of the article is to analyse publications in order to identify public's awareness of radical changes in economic and ecological spheres. The article provides a bibliometric analysis of research in the field of green deal policy, energy conservation and energy efficiency through the introduction of renewable energy sources. The authors selected 337 papers which were published in 1999-2019. Scopus provided the database for analysis. By means of VOSviewer the results of bibliometric analyses were visualized in a definitions map. It allowed identifying six clusters that combine 131 terms. As a result of the research, the connection between the terms – renewable energy sources and energy saving – was revealed with the help of the constructed bibliographic map.

Keywords: green economy, green deal policy, renewable energy sources, energy saving, energy modernization, energy security, carbon-neutral economy

JEL Classification: Q42

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1.Introduction

After the tragic radiation accident on March 11, 2011 at the Fukushima-1 nuclear power plant (Japan), which became the largest accident in the nuclear power industry after the Chernobyl accident (1986), almost all countries reconsidered their priorities in the energy sector and began to carry out reforms on modernization and re-profiling of energy production. The most prospective directions were alternative energy sources and the transition to a carbon-neutral economy. For example, the EU countries have agreed on the Energy Efficiency Action Plan for 2007-2020 (Verkhovna Rada of Ukraine, 2006), which is a 20-20-20 Plan to reduce CO_2 emissions by 20%, to increase energy efficiency by 20% and to increase the share of renewable energy sources in the energy sector by 20%. Ukraine's plans at this stage are to reach 11% of renewable energy sources in the structure of final energy consumption and increase the level of energy saving by 9%. At the same time, Ukraine, which has acceded to the Paris Climate Agreement, has set a goal - to reduce CO_2 emissions by 40% by 2030 as compared to 1990 (Verkhovna Rada of Ukraine, 2016).

But taking into account that almost all partner countries have met the targets by 2020, strong investment potential and opportunities of the EU allowed not stopping at the first successes, and in mid-2019 the European Commission announced a new European Green Deal (European Commission, 2020), which was presented on December 11, 2019. The European Green Deal covers all sectors of the economy and consists of eight main strategic targets: a climate ambition (Formation and development of the “Climate Law”); clean, affordable and secure energy (Regulation of the energy sector and development of the smart sector integration); an industrial strategy for a clean and circular economy (the EU industry reform); a sustainable and smart mobility (encouragement of the alternative fuels production, development of infrastructure for cars running on alternative fuels); greening the Common Agricultural Policy/a “Farm to Fork” Strategy (development of the measures to ban the use of inorganic fertilizers and pesticides in farming); preserving and protecting biodiversity (measures to protect forests and biodiversity); towards a zero-pollution ambition for a toxic free environment; mainstreaming sustainability in all the EU policies (European Commission, 2020).

The European Green Deal is a roadmap for the transition to a carbon-neutral economy, taking into account the competitiveness of a clean economy and sustainable development, living standards and health. The main goal of the green policy is economic growth decoupled from the resource use.

Achieving the ambitious results of the European Green Deal is not possible without all countries’ participation, because the climate change and CO_2 emissions are global in nature, and solving these problems on one continent will not be of much benefit to the whole world. That is why the EU campaigns all countries for joining the Green Agreement and developing economic relations on equal competitive conditions.

In January 2020, Ukraine supported the EU initiative and agreed to cooperate in the areas of decarbonisation of the environment and become an integral part of the European Green Deal.

2. The Literature Review

Nowadays, a large number of scientific papers are devoted to studying the feasibility of introducing renewable energy sources in the context of energy conservation and energy security of the country.

A large number of articles (Ziabina, 2016; Dkhili, 2018; Lyulyov et al., 2015; Bilan et al., 2019; Palienko & Lyulyov, 2018) are devoted to the theoretical analysis of the "green" economy and macro- and micro-indicators that affect its sustainable development.

In the scientific works by (Bigerna et al., 2019; Prokopenko et al., 2017; Cebula & Pimonenko, 2015; Yevdokimov et al., 2018; Bogachov et al., 2020; Boiko et al., 2019; Czyżewski et al., 2019; Chygryn et al. 2020; Dalevska et al., 2019; Dementyev & Kwilinski, 2020; Drozdz et al., 2019; 2020; Dzwigol, 2019a; 2019b; 2020a; 2020b; 2020c; Dzwigol & Wolniak, 2018; Dzwigol & Dźwigoł-Barosz, 2018; 2020; Dzwigol et al., 2019a; 2019b; 2019c; 2020a; Furmaniak et al., 2018; 2019a; 2019b; Kharazishvili et al., 2020; Kondratenko et al., 2020; Kuzior et al., 2020; Kwilinski, 2017; 2018a; 2018b; 2018c; 2018d; 2019; Kwilinski et al., 2019a; 2019b; 2019c; 2019d; 2019e; 2019f; 2019g; 2020a; 2020b; 2020c; 2020d; Kwilinski & Kuzior, 2020; Kyrylov et al., 2020; Lakhno et al., 2018; Lyulyov & Pimonenko, 2017; Miskiewicz, 2017a; 2017b; 2018; 2020; Miśkiewicz & Wolniak, 2020; Pająk et al., 2016; 2017; Pimonenko & Lyulyov, 2018; Pimonenko et al., 2018; Prokopenko & Miśkiewicz, 2020; Saługa et al., 2020; Savchenko et al., 2019; Tkachenko et al., 2019a; 2019b; 2019c; 2019d; 2019e; Yelnikova & Miskiewicz, 2020), special attention is paid to sustainable development in the context of promoting renewable energy sources and digitalizing processes in the EU. Namely, the introduction of carbon-neutral development taking into account the potential economic, climatic and social opportunities of each region in combination with the EU environmental policy.

The articles by (Pimonenko et al., 2018a; Lyulyov et al., 2015; Vanickova, 2020; Chygryn et al., 2018) consider the essence of green investing as one of the effective methods of developing a carbon-neutral economy in Ukraine and in the world as a whole. They distinguish such a notion as «greenwashing» and its features in the field of marketing communications in the green investment development.

The works by (Chygryn, 2018; Matsenko et al., 2011) consider the main tendencies of global consumption, including «green» consumption as a systemic and holistic approach that influences the development of renewable energy sources in the world.

The article by (Chel, 2009) "Building Integrated Renewable Energy Technologies: Embodied Energy, Economic Analysis and Potential of CO_2 Emission Mitigation" reveals the main directions of increasing energy efficiency and energy conservation through introducing solar photovoltaic panels, heating devices, wind turbines, etc.

Sineviciene Lina, Sotnyk Iryna, Kubatko Oleksandr (Sineviciene et al., 2017) analysed in their study the terms “energy efficiency” and “energy consumption” in Eastern Europe of 1996-2013. According to their study results, the dependence of the GDP level on energy efficiency and energy consumption was established.

In a scientific study, (Wiginton et al., 2010; Lyulyov & Shvindina, 2017) prove the relevance of solar photovoltaic technology and present a developed five-stage model for assessing the photoelectric potential of the roof of a house, taking into account geographical, climatic and technical aspects.

The article «Minimising Carbon Footprint of Regional Biomass Supply Chains» (Lam et al., 2010) presented a regional approach targeting energy-oriented demand, which is used to assess possible ways to transferring energy from renewable sources to consumers in the certain region.

Publications concerning the countries with underdeveloped energy systems, including African countries, should also be considered. Africa today can become a global hub in «green» energy given the continent's natural potential. Thus, the study «Energy and Sustainable Development in Nigeria: The Way Forward» (Oyedepo, 2012) presents the relation between energy supply and socio-economic development of the country. The article reveals the main problems associated with frequent power outages, especially in remote areas, as well as environmental problems with the use of fossil fuels for energy.

John-Felix K. Akinbami presents the main obstacles to producing renewable energy sources and provides recommendations for optimal and consistent transition to alternative energy supply in terms of reducing CO_2 emissions and economic growth and development (John-Felix, 2001).

It is also worth noting the research (Akinwale et al., 2014) based on opinion polls related to understanding the Nigerian population in the relevance and feasibility of introducing renewable energy sources. The results also show that the population is willing to pay more for electricity on the condition of an uninterrupted supply.

3. Methods

The search for relevant information for bibliometric analysis took place in several successive stages *(Figure 1).*

In the first step, shown in *Figure 1*, the search query in the Scopus database using the “AND” command consisted of such key basic concepts as “renewable energy sources” and “energy conservation” in the “title, abstract, keywords” category. The number of results obtained at this stage was 896 scientific sources.

For the clarity of this study, in the second stage of this array of information the scope of research was narrowed to the following scientific domains: “Economics, Econometrics and Finance,” “Multidisciplinary,” “Business, Management and Accounting,” “Social Sciences.” The number of documents received at the end of the second stage was 337, which reveals the problems of energy efficiency and the use of renewable energy sources in the economic and social spheres. All data were saved and processed using the Excel software.

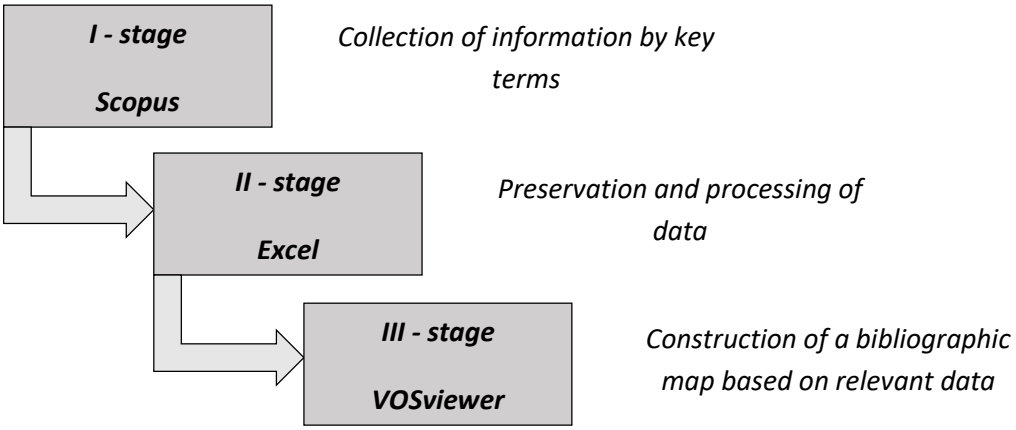

Figure 1. The Stages of Bibliometric Research
Source: developed by the authors.

In the third stage, a bibliographic map based on the relevant Scopus data was constructed using the VOSviewer research visualization and clustering analysis tool. VOSviewer is a software designed to build and visualize bibliometric links.

The bibliometric analysis using VOSviewer made it possible to identify 131 out of 2483 keywords, which corresponds to the threshold and the minimum number of occurrences in the title, keywords and abstract - 5.

4. Results and Discussion

In the course of information processing, there was a growing interest in researching the implementation of renewable energy sources, and improving energy efficiency. *Figure 2* shows the results of the publishing activity analysis in a particular direction.

The results of the analysis show that, compared to 2009, in 2018 the number of scientific publications increased almost fourfold. According to the constructed trend line, it can be noted that the rapid growth of publishing activities on the selected topic has increased significantly since 2012, due to the active work of many countries in the direction of converting the energy sector to renewable energy sources and reducing nuclear and fuel energy to a minimum and reduction of CO_2 emissions.

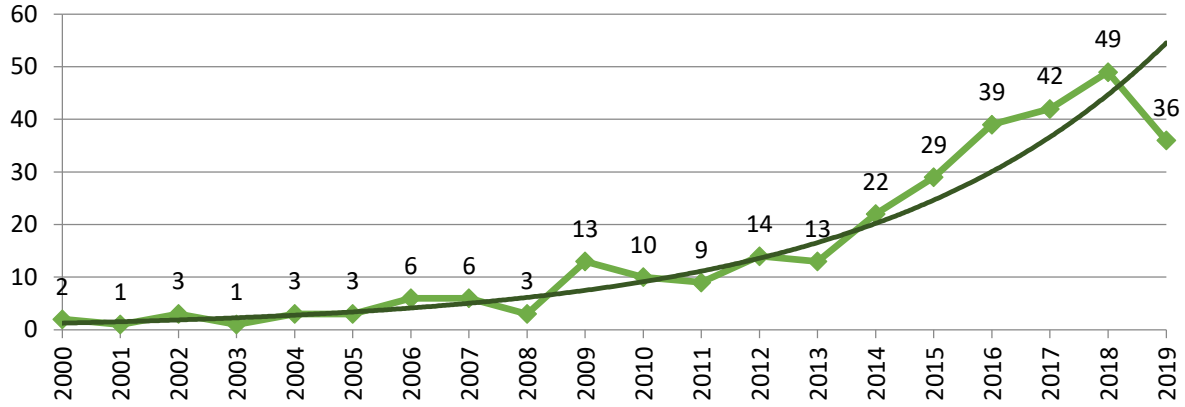

Figure 2. The Dynamics of Published Documents in the Period of 2000-2019
Sources: developed by the authors based on Scopus (2020).

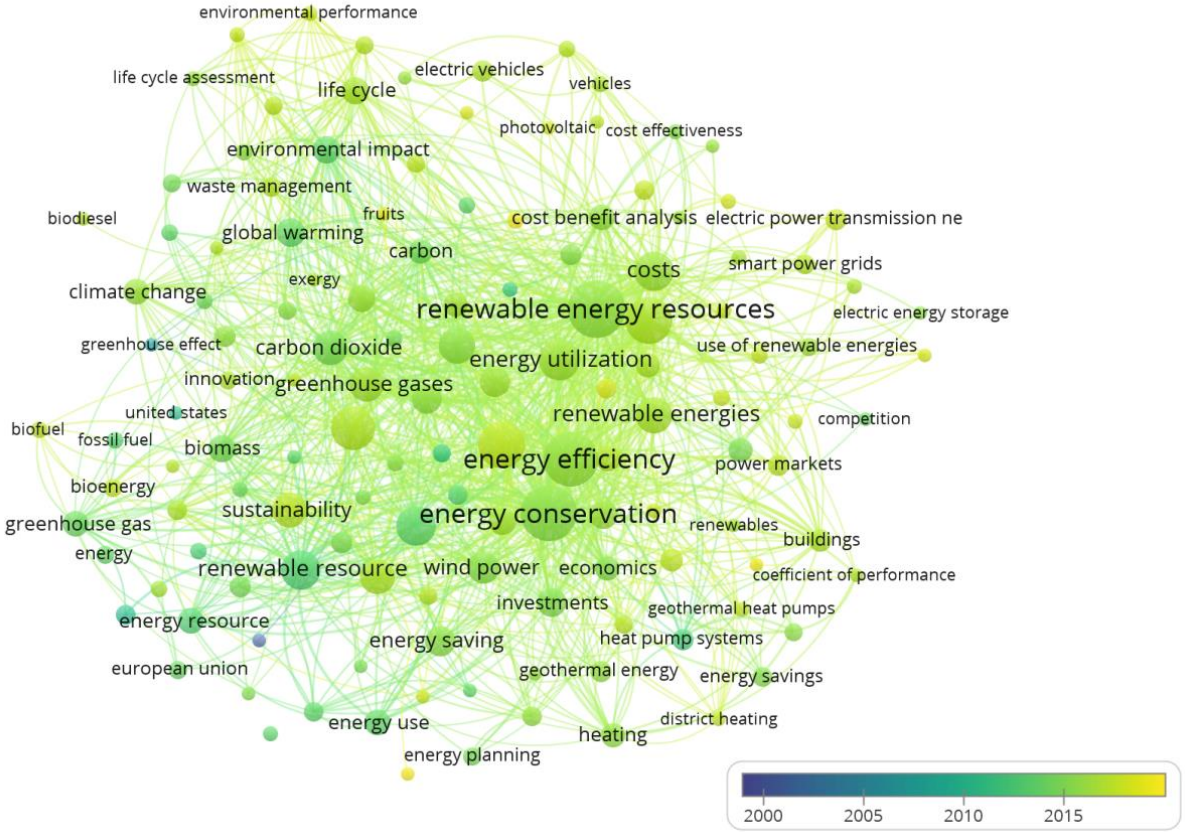

Figure 3. A Bibliometric Map of the Keywords in the Investigated Articles (2000-2019).
Source: developed by the authors based on VOSviewer (2020).

From the constructed bibliographic map (*Figure 3*) it is possible to note a certain evolution vector of the research urgency in the field of developing renewable energy sources. In the period of 2015-2017, scientists actively began to study issues of energy conservation, energy efficiency, alternative energy sources, global warming, neutral carbon economy, etc. It was during this period that the EU countries announced the first successful effects of the Directive 2009/28/EC adopted by the European Parliament and of the Council as of 23 April 2009 on promoting the use of energy from renewable sources in developing renewable energy sources due to the use of energy-saving technologies in the household and industry (LIGAZAKON, 2009).

During the established period of time (2000-2020) the results of research on renewable energy sources and energy conservation were published: articles – 237, conference papers – 55, book chapters – 24, reviews – 13, books – 2, and etc. The results of scientific works have been tested in more than 60 professional publications – Journal of Cleaner Production (42), Sustainability Switzerland (23), International Journal of Energy Economics and Policy (16) Sustainable Cities and Society (11), International Conference on the European Energy Market Eem (8) etc. *Figure 4* shows twenty countries with the largest number of published research examining the problems of energy saving and energy efficiency in implementing renewable energy sources in the field of «Economics, Econometrics and Finance», «Multidisciplinary», «Business, Management and Accounting», «Social Sciences» from 2000 to 2019 to the Scopus database.

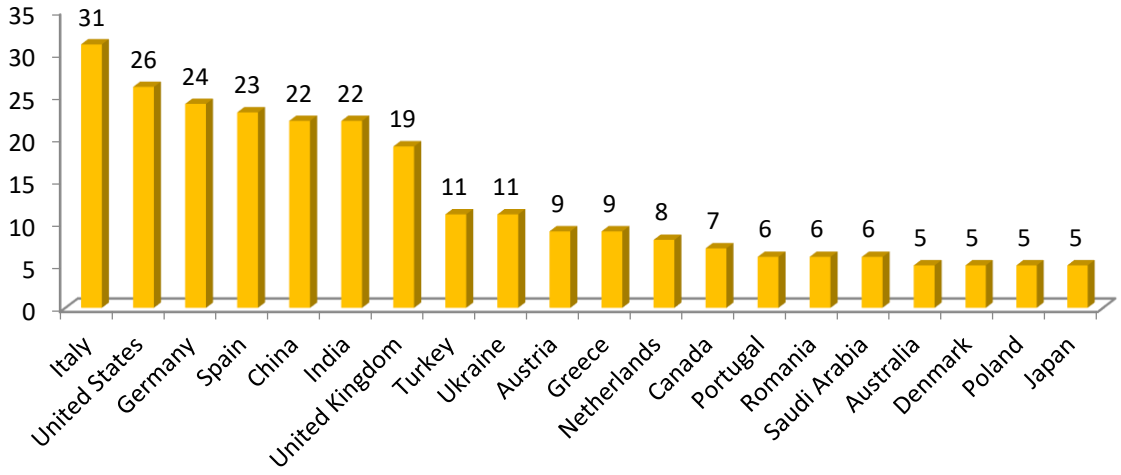

Figure 4. Top 20 Countries in Terms of Quantitative Dynamics of Publishing Activity, 2000-2019.
Source: developed by the authors based on (Scopus, 2020).

It should be noted that in some countries there is a direct relation between publishing and progress in implementing renewable energy sources and increasing energy efficiency. Namely, Italy is the leader in the number of publications on energy efficiency and renewable energy in the economic sphere. This country is among the top 10 EU countries that at the beginning of 2017 implemented the" Plan 20-20-20" regulated by Directive 2009/28/EU of the European Parliament and of the Council as of 23 April 2009 on promoting the use of energy from

renewable sources. At the beginning of 2017, Germany, Spain, Great Britain, Greece, Poland and Portugal failed to reach 20% of renewable energy sources in the structure of the energy complex (LIGAZAKON, 2009). Ukraine ranks 9th in the number of publications studying the selected problems in the field of economics - this is due to the Ukrainian scientists' participation in a large number of both domestic and foreign research programs and grants. Let us consider in more detail the cluster map of cooperation in the publishing field of the research domain presented in *Figure 5*.

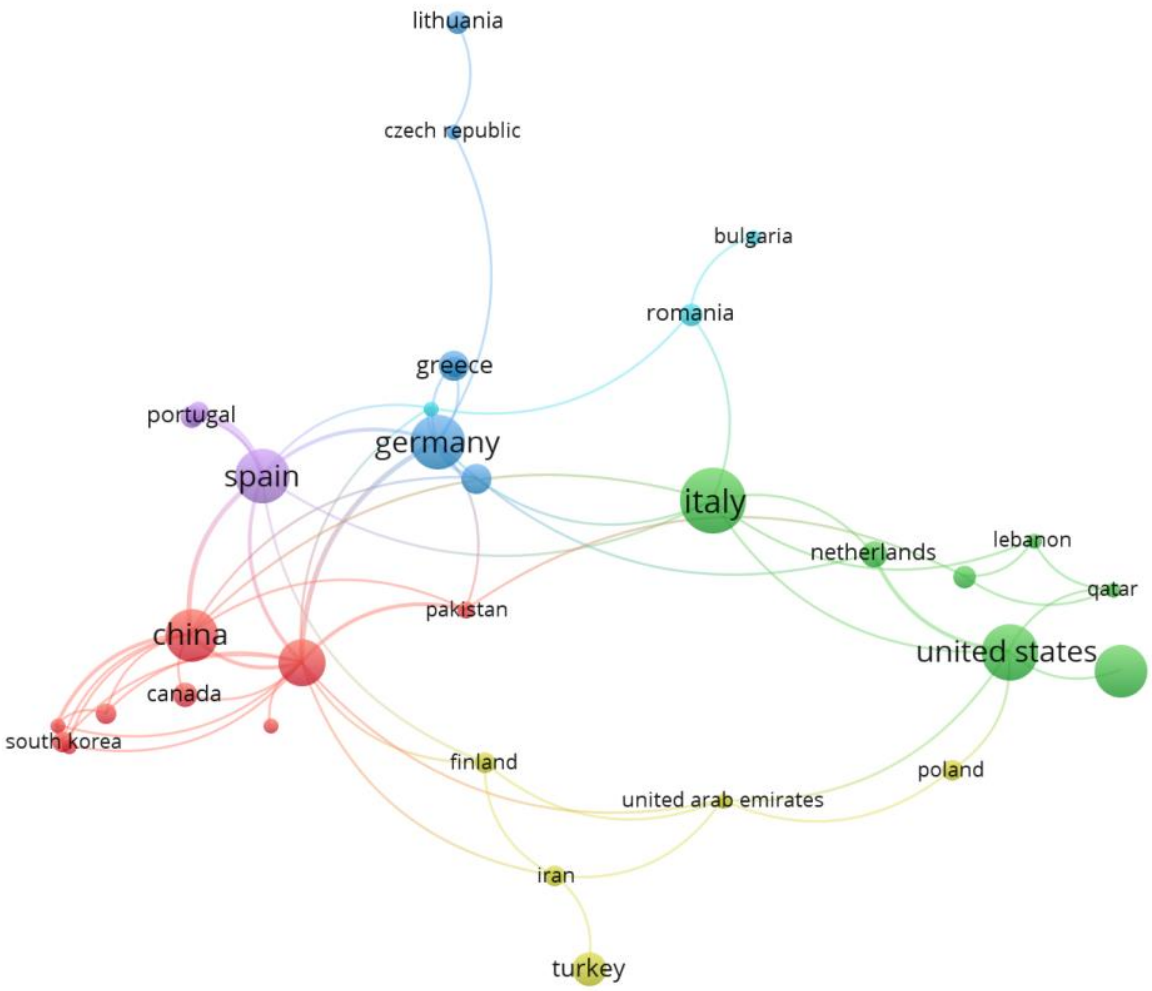

Figure 5. A Bibliometric Map of the Analysed Documents by Countries Published between 2000-2019.
Source: developed by the authors based on VOSviewer (2020).

Thus, we can distinguish six clusters of co-authorship. The red cluster is the largest (nine countries), uniting the countries of Europe, Asia and Africa. The green cluster includes eight countries (including the USA, Italy, and India). The blue cluster comprises only 6 EU countries. The yellow cluster covers the EU and the Middle East. However, the last two clusters of purple and blue colours show the co-authorship of the EU countries in the publications studied.

From the researched data set, the first 10 articles with the largest number of citations were selected, and the studied publications were analysed (*Table 1*).

Table 1. Field-Weighted Citation Impact of Top-10 Cited Articles

Rank	Journal	Title	Year of publication	Citations	Field-weighted citation impact
1	Energy, Sustainability and Society	Hydrogen from Catalytic Reforming of Biomass-Derived Hydrocarbons in Liquid Water	2002	1574	2,35
2	American Association for the Advancement of Science	Ethanol for a Sustainable Energy Future	2007	841	17,98
3	Energy, Sustainability and Society	A Molecular Molybdenum-Oxo Catalyst for Generating Hydrogen from Water	2010	475	5,6
4	Energy Economics	Energy Consumption and Economic Growth: Evidence from China at Both Aggregated and Disaggregated Levels	2008	348	8.44
5	Computers, Environment and Urban Systems	Quantifying Rooftop Solar Photovoltaic Potential for Regional Renewable Energy Policy	2010	210	7.75
6	Technovation	Hydrogen: The Energy Source for the 21st Century	2005	173	15.62
7	Resources, Conservation and Recycling	Minimising Carbon Footprint of Regional Biomass Supply Chains	2010	133	8.93
8	Energy, Sustainability and Society	Energy and Sustainable Development in Nigeria: The Way Forward	2012	126	2.02
9	Transportation Research, Part D: Transport and Environment	Training Urban Bus Drivers to Promote Smart Driving: A Note on a Greek Eco-Driving Pilot Program	2007	107	1.09
10	Proceedings of the National Academy of Sciences of the United States of America	Dependence of Hydropower Energy Generation on Forests in the Amazon Basin at Local and Regional Scales	2013	103	2.62

Source: developed by the authors based on Scopus (2020).

Table 1 shows the top 10 items that explore the development and problems of implementation of renewable energy sources and their impact on energy efficiency in the

economic sphere. The relevance and appropriateness of the article is assessed by several indicators, including the number of citations and Field-Weighted Citation Impact (FWCI) - the ratio of the total number of citations actually received to the total number of citations that can be expected based on the average value of the subject field.

The article with the largest number of citations (Cortright et al., 2002) reveals questions about alternative ways of hydrogen production not only from natural gas and oil, but also from renewable sources, including water and biomass. This is a very relevant study, because hydrogen is used in many areas of production: fuel (rocket fuel and coolant), food industry (food additive E949), chemical industry (in the production of soap, methanol, plastics), meteorology, etc.

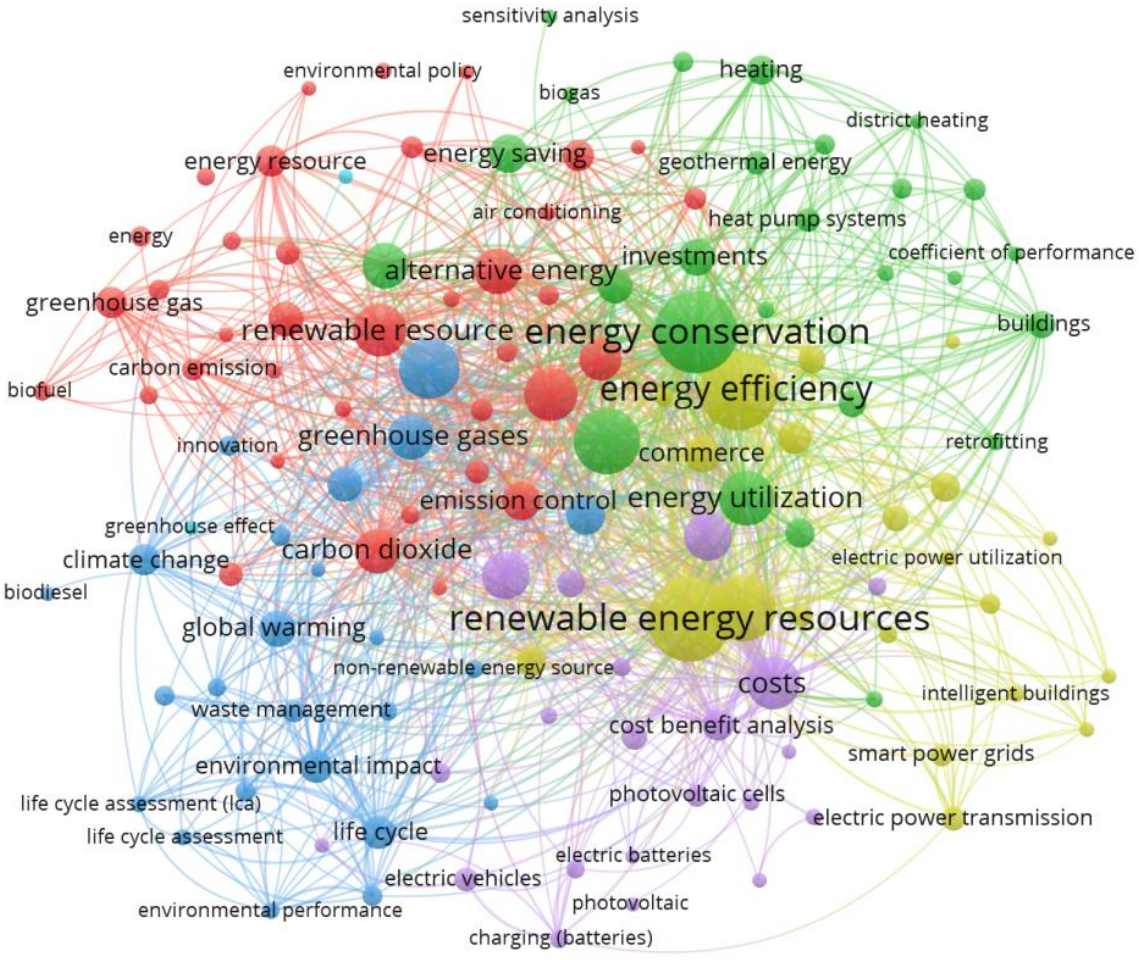

Figure 6. A Bibliometric Map of the Keywords in the Investigated Articles, 2000-2019.
Source: developed by the authors based on VOSviewer (2020).

In second place in *Table 1* is the article (Goldemberg, 2007) with the largest Field-Weighted Citation Impact, which explores issues related to producing ethanol from sugar cane, and its processing into environmentally friendly fuel, which is gaining popularity today. Ethanol is a

substance in demand today and is widely used as a fuel in the chemical and food industries, in medicine, as well as in the production of perfumes, etc.

The research of thematic focus publications have been carried out by a visualization tool and analysis of clustering research VOSviewer, which allowed building a bibliographic map (*Figure 6*) of terms such as renewable energy, energy conservation and energy efficiency with a minimum number of occurrences in the title, keywords and abstract - 5 times.

As a result of constructing the terminological map, 5 clusters were identified, which united the key concepts in terms of thematic proximity. The main criteria for reading a bibliographic map are the size of the circle (characterizing the frequency of use of the term) and the length of the line (visualizes the strength of the connection between the concepts). Thus, the first cluster is red and includes 37 keywords, such as renewable resource, energy resource, carbon dioxide, energy market. This cluster was given a conventional name 'energy'.

In the "green" cluster there are 26 main terms, including renewable energy, energy conservation, energy saving, investments. Thus, the second cluster will be given a conventional name 'energy conservation'.

The third cluster has a conventional name 'sustainable development' and includes 26 keywords: life cycle, climate change, global warming, and is of blue colour.

The fourth cluster is yellow and is called 'renewable energy resources'. It includes 21 terms such as energy efficiency, renewable energy resources, commerce, energy management.

The purple cluster No 5 with a relevant name 'costs' includes 21 terms: costs, cost benefit analysis.

Considering all the clusters of the terminological map, we can conclude that the main terms under study – renewable energy and energy conservation – are interrelated, as evidenced by the lengths of the connecting lines, although they belong to different clusters. It is also necessary to note the sizes of circles which designate analysing terms: they are big enough compared to others, which gives understanding of the dynamics of their use in research.

5. Conclusions

Research of scientific results using the Scopus database provides great opportunities to present relevant and reliable information published by scientists around the world. Thus, such research is of great importance for further directions of developing scientific theories, views, etc. The bibliographic analysis consisted of such key basic concepts as "renewable energy sources" and "energy conservation" in the category "title, abstract, keywords." The results account for 896 scientific sources. The number of publications decreased after filtering according to the scientific areas: "Economics, Econometrics and Finance," "Multidisciplinary," "Business, Management and Accounting," "Social Sciences," and decreased to 337, which

reveals the problems of energy efficiency and renewable energy sources in economic and social spheres. The tool for visualization and analysis of clustering the scientific research, VOSviewer, allowed achieving the goal set with the necessary degree of detail. Thus, the bibliometric analysis identified 5 main clusters, which visualized the results of the study and allowed proving the dependence of the main research terms: renewable sources and energy efficiency.

Thus, from the above material we can draw the following conclusions.

First, according to the terminological map, the relation between the terms 'renewable energy,' 'energy saving' and 'energy efficiency' is strong and dynamic. Accordingly, these three main terms have approximately the same time of occurrence in the scientific research. Energy saving is based on two main factors:

1) introduction and use of renewable energy sources;

2) energy efficiency of equipment that supplies and produces energy, as well as the facilities themselves, which must retain and receive energy from the environment as much as possible.

Secondly, during the study of publications, new directions in producing alternative energy sources in transition to a carbon-neutral economy were identified.

Thirdly, it could be forecasted that in the process of studying the field of green deal policy research, the number of publications will increase as a new cycle in developing a neutral carbon economy is about to begin.

6. Formatting of Funding Sources

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