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ENERGY-EFFICIENT INNOVATIONS: MARKETING, MANAGEMENT AND LAW SUPPORTING

Abstract. *This paper summarises the arguments and counterarguments within the scientific discussion on the issue of promotion energy-efficient innovations by marketing, management and law supporting. The innovative development is considered to be an essential condition to provide a high level of social and economic development. Thus, energy-efficient innovations are considered to be among the most critical drivers of qualitative economic growth and increasing the country's competitiveness in the world market. Systematisation literary sources and approaches for solving the problem of promoting energy-efficient innovations indicated that government and scientists give the powerful punch in energy-efficient development. In view of this, it is appropriate to do the bibliometric research on publication activity on energy-efficient innovation from law aspect. The primary purpose of the study is to analyse the structure and dynamic of scientific publications in the field of energy-efficient legislation in the economic subject areas. The object of study is the chosen publications indexed in the Scopus database by keywords such as: «energy-efficient innovations», «energy law», «environmental legislation», «energy-efficient policy» in the category «title, abstract, keywords». The current study involved data from 1913 papers published on 13 languages in the subject area «Business, Management and Accounting» and «Economics, Econometrics, and Finance» from 2000 to 2019. Using VOSviewer, bibliometric analysis of publications on the issue of energy-efficient legislation was conducted from the view of the publication activity dynamic, considering the most impact articles, and countries in the issues of energy-efficient legislation researches. According to the obtained results, the increasing dynamic of publication activity from 2000 to 2019 was detected. Furthermore, it was visualised four clusters of countries' collaborations by co-authorship as follows: 1) between the USA, the EU countries (including the United Kingdom) and China; 2) the EU countries, as well as South American such as Brazil and Chile; 3) African countries and the EU countries; 4) between Asian and African countries. Furthermore, the authors highlighted the most influencing articles in the field of energy-efficient innovations that could be the basis for future investigations promoting innovative activity in the field of energy-efficient development.*

Keywords: bibliometric analysis, energy-efficient innovations, environmental legislation, energy policy, Scopus, VOSviewer.

Introduction. Nowadays the EU energy efficient policy includes: the general political and regulated base, established by the energy efficiency directive 2012/27/EU and the EU plan action to increase the energy-efficiency; the national plan's action in the field of energy-efficiency, which should include the realistic plans corresponding the ones established on the level of EU indicative goals; the EU particular documents in the directions of energy-efficient development; the corresponding tools such as the particular purpose funding, disseminating information as well as supporting the individual networks, etc. It worth noting that the energy efficiency directive 2012/27/EU has set the indicative energy-saving target on the level of not less than 32.5% by 2030. Moreover, the one demands from the EU members to set the indicative national contributions in the field of energy efficiency. In addition to that, the EU countries should take into account the energy consumption level of the EU to 2030 (Kaveshnikov, 2014).

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According to the above mentioned, the most popular methods to increase the energy-efficient level in the EU were detected as follows: the statutory technical standards; stimulating procedures to develop voluntary standards by the business sector; energy-saving tariffs; tax incentives; allowance during government procurement; creating demand on the energy-efficient goods; co-funding of the pilot energy-efficient projects; coordinating the researches and networking among scientists, as well as between scientists and business sector, etc.

The systematisation of the scientific sources in the field of energy-efficiency (Brychko et al., 2018; Sokolenko et al., 2017; Panchenko et al., 2018) indicated several barriers were holding energy-efficient development in the EU countries. Firstly, it is economic stagnation. Despite the fact that the energy-efficient investments would be able to provide a substantial saving in the long-term period, most of the EU countries are not to invest heavily in the energy-efficient technology and development of energy-efficient innovations. Secondly, the EU members haven't been ready to delegate complete authority in the field of energy-efficiency because of different national energy systems. Due to this, the EU isn't able to provide a more highly regulated energy industry. That is why the EU activity in stimulating energy-efficient growth is caring in the frame of the open coordination method, which consists of two elements as follows: indicative planning and monitoring on the national activities, as well as a system of statutory technical standards. However, the proactive attitude on the national level highly dependent on the county's policy and resources. Thus, it is expected in the condition of the lax control (open coordination method), the EU countries would minimise their forces in achieving the EU declared goals in the field of energy efficiency. Based on a great interest in investigating the issues on energy-efficient innovations, it is appropriate to do the bibliometric research on publication activity on energy-efficient innovation from the law aspect, partly, because of a massive pile of different bibliographic information, which needs the new quality forms of analytical and system processing. In turn, the article aimed to analyse the structure and dynamic of scientific publications in the field of energy-efficient legislation from the economic viewpoint. In the frame of this article, the research question is: Which development of publication activity in the field of energy-efficient innovations from the law aspects is presented in the Scopus database from 2000 to 2019? On the base of the bibliometric analysis, qualitative info metrical researches are possible. As a result, it is an excellent opportunity to contribute to further development in the field of developing energy-efficient innovations.

Literature Review. The summarisation and systematisation of scientific sources indicate on a considerable research background devoted to investigating the issues on energy-efficiency among national and foreign scientist (Ibragimov et al. 2019; Bilan et al., 2019; Pimonenko et al., 2019; Bunse et al., 2011; Allcott et al., 2012; Herring et al., 2007; Ukey et al., 2017; Feng et al., 2015). Because of this, in the studies (Godden, et al., 2018) considered innovative energy technologies to develop smart infrastructure. The authors indicated that the building of smart infrastructure requires strong legal regulation.

The scientific papers (Yanchenko et al., 2017; Suzuki, 2015) aimed at reviewing the regulations and mechanisms of standardisation to improve the ecological situation in the specific regions. Moreover, in the frame of this article, the international environmental regulation was described in order to check the possibility to apply in on the national level. In addition, in the researches (Carlini et al., 2017) tried to predict Europe's energy future on the base of renewable energy, energy efficiency as well as consumer empowerment. In turn, the American scientists Lenox C.S. and Louhlin D.H. (Lenox and Louhlin, 2017) noted that the last predictions on CO₂ emission in the USA were lower compared to forecasts made ten years ago. The authors supposed that improving energy efficiency and launching technological innovations were among the factors that contributed to lower predictions. Moreover, they noticed that renewable portfolio standards, smart growth initiatives, climate regulations, etc. boost such changes in CO₂ emission.

In the scientific article (Pan at el., 2019) was aimed to evaluate the dynamic relationship among technological innovations, energy efficiency as well as environmental regulation. Based on the analysis, the authors found out the strong impact of technological innovations on promoting energy-efficient development.

Moreover, one was noted that technological innovations relate to incentive environmental regulation of the market. Furthermore, the authors of research (Rak, 2018) described how the legal and environmental regulations involve the enterprises to implement technological and product innovations to boost energy efficiency. Furthermore, the authors of research (Cheng et al., 2019) have analysed how energy and environment were coordinated under environmental regulation. They noted that investments in research and development could prevent environmental pollution intensity. Thereby, the researches in the papers (Vairamohan, et al., 2017; Yanchenko, et al., 2018; Frohling, et al., 2015) emphasised on the role of technological innovations supported by government procedures in boosting the energy-efficient development.

Methodology and research methods. In this article, the most relevant data retrieval to achieve the aim of the research was conducted into several steps. Firstly, based on the Scopus database (Scopus, 2020), a search request of published works including the following keywords such as «energy-efficient innovation*», «energy law», «environmental legislation», «energy policy» was made in the category «title, abstract, keywords». The advanced search of publications on energy-efficient legislation in the Scopus database was conducted using logical operator «OR». Thus, the result showed the articles where at least one keyword was in the title, abstract and keywords.

Moreover, to include the plural number of the keyword «energy-efficient innovation» the sing «*» was used. Then, obtained articles were polished by excluding the general and unrelated to the current research keywords. Due to it, the specific connections between documents were increased made a positive impact on the result of the analysis. Thus, the present study involved data from 1913 papers published on 13 languages in the subject area «Business, Management and Accounting» and «Economics, Econometrics and Finance» from 2000 to 2019. Based on the Scopus database, bibliometric analysis on the issue of energy-efficient legislation was conducted from the view of the publication activity dynamic, considering the most interested scientists, as well as countries in the issues of energy-efficient legislation researches. Generally, the Scopus database serves to support the productive researchers' work process helping them count new publications in the field of their specialisation; to get information about publication author; to keep themselves informed about the most cited articles in the area of their interest; to evaluate the quality of publications; to analyse their achievements based on the h-index, etc.

In the second stage, the visualisation of the thematic group of terms was conducted using the VOSviewer bibliometric tool. Thus, due to VOSviewer, it is possible to develop a map based on the gathered data network of publications. In turn, the terminological map was created by using the technology of highlighting the clusters. Moreover, the maps could be created in different ways; each of them indicates their particular aspects. For instance, VOSviewer creates the map of publications, journals based on the network of co-citing or develops the map of keywords on the base of their concurrent appearing (VOSviewer, 2020).

It should be noted, the colours of circles mean belonging to the clusters, their size implies the number of published documents according to the indicated parameter such as co-authorship, co-occurrence or co-citation. The distance between circles stated the frequency of items appearing. The longer distance between circles, the less relation between them is. In turn, the link shows the number of interactions one item with related others, and the total link strength demonstrates the total number of items per one circle or between two analysed circles.

Results. Systematisation and summarisation of scientific resources in the investigated field (Kozmenko et al., 2011; Vasylieva et al., 2017; Myroshnychenko et al., 2019) indicated on increasing the energy-efficient level was the important task for social and sustainable development. In addition, the energy-efficient growth would provide the process of stable long-term development of different economic industries. In turn, the authors (Mentel et al., 2018) noted that innovations in the field of energy efficiency had the most significant contribution to its development. The study (Vasylieva et al., 2018) emphasised that the success of gaining the indicative goals to increase the energy-efficient level should be legislatively supported. Furthermore,

(Pakhnenko et al., 2018) paid attention to the necessity to promote energy-efficient technologies using an effective marketing strategy.

The establishment and distribution of duties between the subjects of the energy systems are the determinants of effective policy consolidative in sustainable development. Given this, creating an effective collaborative mechanism and control function of the government structures are necessary to provide the consistent policy and sustainability of obtained results. According to (Pimonenko et al., 2017) there are several groups of factors that have an impact on the energy-efficient level as follows: technical and technological; organisational and legal; organisational and economical; financial. In the frame of this work, on the base of bibliometric analysis, the energy-efficient innovations were considered in the view of marketing, management, and law supporting. The analysis of the publication dynamic in the investigated field was conducted on the base of the Scopus database. Using the keywords as follows: «energy-efficient innovation», «energy law», «environmental legislation», and «energy policy» the publications were analysed in the subject areas «Business, Management, and Accounting» and «Economics, Econometrics, and Finance». Moreover, to make the initial data clearer, the keywords were checked, excluding the unappropriated ones. As a result, 1913 publications were obtained during 19 years between 2000-2019.

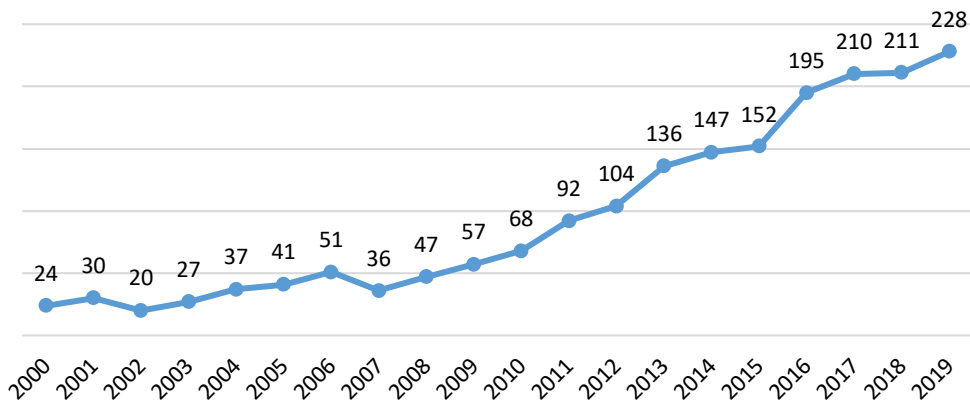


Figure 1. The dynamic of published documents for 2000-2019

Sources: developed by the authors based on (Scopus, 2020)

Figure 1 demonstrated the quantitative dynamic of publication activity from 2000 to 2019. Accordingly, the fast growth in publishing articles has begun since 2008. Thus, the number of publications has increased by more than nine times. It worth noting boosting published documents in the field of energy-efficient innovations in 2016. Thus, in 2016 the number of documents increased by 22% compared to 2015. Such interest in publication activity could be explained by accepting the sustainable goals by the UN on 25 September 2015. In turn, one of the abovementioned goals expects the energy-efficiency would be increased twice to 2030. Given this, the scientists intensified their force in exploring the possibility of expanding the development of energy-efficient innovation based on marketing, management, and law supporting.

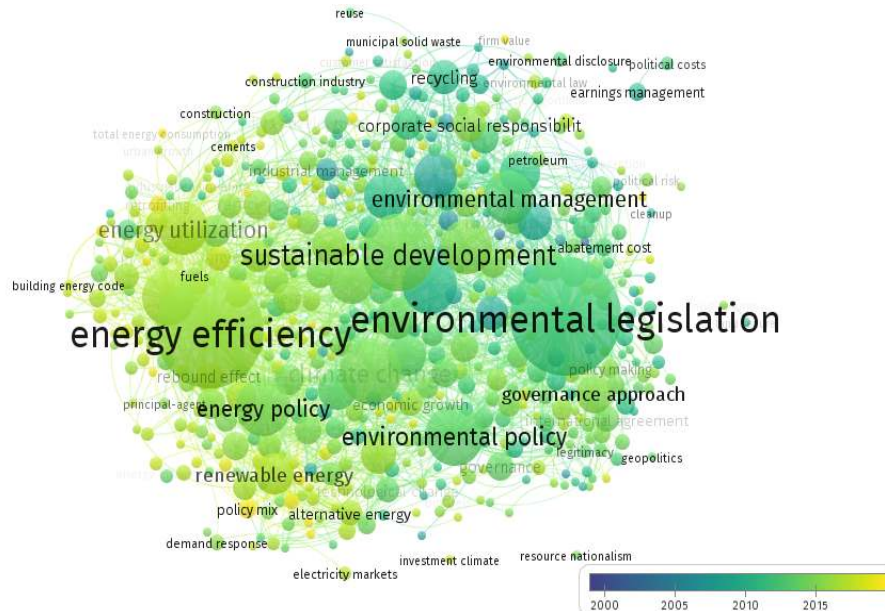


Figure 2. Bibliometric map of the keywords in the investigated articles 2000-2019
Sources: developed by the authors based on (VOSviewer, 2020)

In the frame of this article, the bibliometric analysis was conducted using the bibliometric tool VOSviewer. As a result, the map of keyword co-occurrence was created on the base of Scopus bibliographic database files. The limitation parameter of 3 minimal number of keyword occurrences in the names, keywords, and abstracts of the chosen documents was set. In turn, of the 6040 keywords, 656 met the threshold. The bibliometric tool VOSviewer calculated the total strength of the co-occurrence links with other keywords for each of the 656 keywords. Based on the conducted program calculation, the keywords with the highest total link were selected and visualised on the network map (Figure 2). The obtained results divided into 7 clusters consisted of 520 items. Under the developed terminological map, there were 7606 links between keywords with total link strength 10959

Moreover, it is possible to notice the vector of scientists' publication development. In the period between 2012-2014, the researchers were investigating the issues of environmental legislation, environmental management, environmental policy, etc. Then, the scientists' attention was directed to issues on sustainable development in the period when the Paris agreement was signed, setting the sustainable goals to achieve by 2030. In view of this, since 2016, the scientists' have investigated more specifically energy efficiency, energy policy, renewable energy as well as innovations. In order to find the most impactful scientific journals in the sphere of investigating energy-efficient legislation from economics view, the analysis was conducted using Scopus data (Table 1). Thus, ten scientific journals printed at least 30 documents in investigating fields between 2000-2019 were chosen. In Table 1, based on the number of citations, seven most cited articles were analysed by field-weighted citation impact and sources of publication. It worth noting, the field-weighted citation impact demonstrates to what extent the documents were cited comparing with similar ones. This index bases on the data about the year of publication, document type, and disciplines associated with the source. Thus, field-weighted citation impact is the ratio of the number of document citations to the average number of similar documents' citations over three years. To add, each discipline has equal value for calculation, excluding the differences in researchers' approaches to citation.

Table 1. Field-weighted citation impact of top-7 cited articles

Rank	Journal	Title	Citations	Field-weighted citation impact
1	Ecological Economics	Energy consumption, carbon emissions, and economic growth in China	674	17.09
2	Technological Forecasting and Social Change	Scenarios of long-term socio-economic and environmental development under climate stabilisation	600	13.09
3	Environmental and Resource Economics	Renewable energy policies and technological innovation: Evidence-based on patent counts	585	23.34
4	American Economic Review	Induced innovation and energy prices	497	5.72
5	Ecological Economics	An institutional analysis of payments for environmental services	407	24.27
6	Energy Economics	Energy consumption and real GDP in G7 countries: New evidence from panel cointegration with structural breaks	375	9.23
7	Review of Environmental Economics and Policy	The porter hypothesis at 20: Can environmental regulation enhance innovation and competitiveness?	316	12.31

Sources: developed by the authors based on (Scopus, 2020)

The obtained results indicated that the article «An institutional analysis of payments for environmental services» had the highest field-weighted citation impact (24.27). In contrast, the most cited article was «Energy consumption, carbon emissions, and economic growth in China». Moreover, these articles were published at the same scientific journal «Ecological Economics» that could be the relevant source for search and base for future investigation. Generally, this journal had 107 published articles related to this research criteria during 2000-2019.

The co-authorship analysis of countries could help to notice the collaboration degree between scientists from different countries, as well as their influence on the investigations in the field of energy-efficient innovations. Using the bibliometric tool VOSviewer, the map of co-authorship was built on the base of processed Scopus data. Chosen minimum of three publications per country, the results showed that from 119 countries, 64 met the threshold. In turn, for each of 64 countries, the map visually demonstrates calculations of the highest total strength of the co-authorship links with other countries.

According to the Figure 2, on the base of published documents, top-10 countries investigating the issues on energy-efficiency were United Nations (456), United Kingdom (271), Germany (140), Australia (98), China (97), Netherlands (80), France (79), Italy (64), Spain (60) and Canada (57). In turn, the United Nations had the highest publication activity with 465 documents cited 11683 times published during 2000-2019 in the field energy-efficiency. Furthermore, this country had 182 co-authored documents with other countries.

The network map visualises four main clusters. The first cluster allowed to notice the collaboration between the USA, the EU countries (including the UK) and China; the second cluster visualises the co-authorship mostly among the EU countries, as well as South American such as Brazil and Chile; the third cluster indicated on the collaboration among African countries and the EU countries; the fourth cluster shows the co-authorship relationship between Asian and African countries.

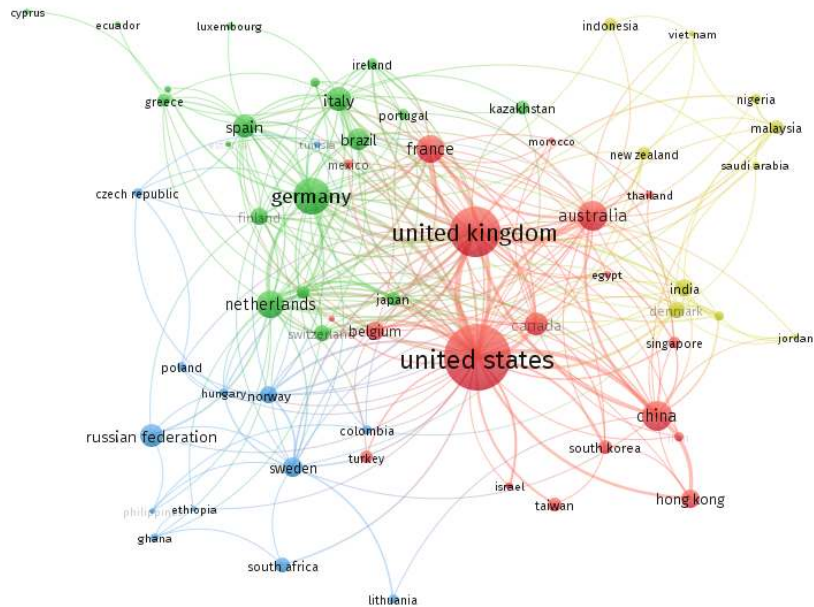


Figure 2. Bibliometric map of the analysed documents by the countries published between 2000-2019

Sources: developed by the authors based on (VOSviewer, 2020)

Conclusions. Investigating the successful examples of advanced experience in energy-efficient development has a high value for policymakers. However, it is difficult to find a universal decision in specific local conditions. In turn, the analysis of publication directions in energy efficiency could help to structure the dynamics of publication activity, which is hard to do without special bibliometric tools. In this study, the bibliometric tool VOSviewer helped to gain the aim of this study. The bibliometric analysis was provided for 1913 articles on the keywords «energy-efficient innovations», «energy policy», «environmental law», «environmental legislation», «energy policy» in the subject areas «Business, Management and Accounting» and «Economics Econometrics and Finance» from 2000 to 2019. The obtained results indicated on the positive tendency in investigating issues on energy-efficient innovations in the view of marketing, management and law supporting between 2000-2019. As a result of the visualisation of keywords, the co-occurrence map was created on the base of Scopus bibliographic database files. The obtained results divided into 7 clusters consisted of 520 items. In accordance with the developed terminological map, there were 7606 links between keywords with total link strength 10959. The analysis of keywords showed the research trajectory of theme development. In turn, between 2012-2014, most of all, the researchers were investigating the issues of environmental legislation, environmental management, environmental policy, etc. Then, the scientists' attention was directed to issues on sustainable development in the period when the Paris agreement was signed, setting the sustainable goals to achieve by 2030. In view of this, since 2016, the scientists have investigated more specifically energy efficiency, energy policy, renewable energy as well as innovations. Moreover, the collaboration between authors from different countries was noticed. The network map visualises 4 main clusters. The first cluster allows seeing the collaboration between the USA, the EU countries (including the United Kingdom) and China. The second cluster visualises the co-authorship mostly among the EU countries, as well as South American such as Brazil and Chile; the third cluster indicated on

the collaboration among African countries and the EU countries; the fourth cluster shows the co-authorship relationship between Asian and African countries. As a result of the VOSviewer and Scopus analyses of the articles indexed in the Scopus database, the most influencing articles in the field of energy-efficient innovations were highlighted that could be the basis for future investigations promoting innovative activity in the field energy-efficient development. It should be noted that this article covers only the publications based on the Scopus database. Given this, it is appropriate to extend the future studies using the published documents in the Web of Science database.

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Енергоефективнi iнновацiї: маркетинг, менеджмент та правова пiдтримка

Стаття узагальнює аргументи та контраргументи в межах наукової дискусії з питання промоції енергоефективних iнновацiй з використанням iнструментiв маркетингу та менеджменту, а також наявної правової пiдтримки. У роботi зазначено, що iнновацiйний розвиток має суттєве значення у забезпеченнi високого рiвня соцiального та економiчного розвитку. Таким чином, впровадження енергоефективних iнновацiй являються однiєю iз рушiйних сил якiсного економiчного зростання та пiдвищення конкурентоспроможностi країни на свiтовому ринку. Систематизацiя лiтературних джерел та пiдходiв до вирiшення проблеми промоцiї енергоефективного розвитку засвiдчила, що правова пiдтримка та науковi дослідження мають потужний вплив на розвиток та впровадження енергоефективних iнновацiй. З огляду на вищезазначене, у статтi представлено результати бiблiометричного аналізу публiкацiйної активностi вчених у сферi дослідження енергоефективностi. Основною метою статтi є аналіз особливостей та динаміки наукових публiкацiй присвячених розгляду правової пiдтримки, розвитку енергоефективних iнновацiй в економiчних предметних областях. Об'єктом дослідження є публiкацiї, що проiндексованi в базі даних Scopus за такими ключовими словами, як: «енергоефективнi iнновацiї», «енергетичне право», «екологiчне законодавство», «енергоефективна полiтика» у категорiї «назва, анотацiя, ключові слова». Таким чином, вихiдними даними для дослідження обрано 1913 статей, опублiкованих на 13 мовах у предметних областях «Бiзнес, управлiння та бухгалтерський облiк», «Економiка, економетрика та фiнанси». Періодом дослідження обрано 2000-2019 роки. Вiдповiдно до мети дослідження автором проведено бiблiометричний аналіз обраних публiкацiй за критерiями спiвавторства та спiльної появи ключових слiв. Практична реалiзацiя усiх етапiв даного дослідження здiйснено за допомогою iнструментарію програмного забезпечення VOSviewer. Вiдповiдно до отриманих результатiв виявлено зростаючу динаміку публiкацiйної активностi в області дослідження енергоефективностi з 2000 по 2019 рiк. Результати бiблiометричного аналізу дозволили видiлити чотири кластери взаємодiї мiж авторами iз рiзних країн, а саме: 1) мiж США, країнами ЄС та Китаєм; 2) мiж країнами ЄС та Пiвденної Америки, такими як Бразилія та Чилі; 3) мiж країнами Африки та ЄС; 4) мiж країнами Африки та Азії. У свою чергу, авторами визначено та проаналiзовано найбільш впливові статтi в галузi енергоефективних iнновацiй, якi можуть стати основою для подальших досліджень та сприятимуть промоцiї енергоефективних iнновацiй.

Ключові слова: бiблiометричний аналіз, екологiчне законодавство, енергоефективнi iнновацiї, енергетична полiтика, Scopus, VOSviewer.

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