MAPPING THE RESEARCH AGENDA OF ENERGY IN URBAN AREAS: A BIBLIOMETRIC ANALYSIS

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Abstract
The issue of energy in the geographical area of urban spaces represents an area of particular importance, in the current context of a global economy with strong geographical connections.The present paper aims to carry out a bibliometric analysis of scientific production in the field, using the Web of Science (WoS) database, out of which 662 articles, conference proceedings and book chapters were selected. The analysis was performed using the VOSViewer program and several plans / dimensions were analyzed - the editorial and scientific dimension (to identify which is the most widespread form of dissemination for the scientific output and which are the main journals in the area), the territorial dimension (which has considering the geographical distribution of scientific output), the temporal dimension (which studies the evolution over time of the scientific output) and the lexical / semantic dimension (which involves identifying the main keywords of scientific output in the field and the links that exist between them).
Keywords: bibliometric research, text mining, energy, cities, urban areas, VOSViewer, scientific knowledge.

1. INTRODUCTION

Since ancient times, energy has been an important vector of the development of human society, with important effects on the standard of living. This influence of energy has increased in the last century, as the needs of society have increased and the forms of energy have diversified. Basically, at this moment we cannot talk about a community development without illustrating, in one form or another, the role that energy plays. More than that, the concept of "energy management" become more and more important, with great influence on performance of every human activity (Suttipun & Duriyarattakan, 2019).

Moreover, in the last period, the background of unprecedented climate change caused by pollution (melting of the ice from both North and South poles, constant increase of average annual temperatures, extreme phenomena in different regions of the globe, acid rains etc.), but also the rarity of the fossil fuels (Bilgen, 2014), increased the pressure to ensure economic growth and economic development on account of rational (efficient) use of energy resources and large-scale use of renewable energy sources. Thus, there are numerous studies that appreciate that renewable (green) energy, green spaces, reduction of

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CO_2 emissions positively economic growth (Marinescu & Cicea, 2015; Ciocoiu et al., 2014) and the level of health for the population in urban agglomerations (Cicea & Marinescu, 2011; Wolch et. Al., 2014; Bell et al. 2007). Furthermore, in the last few decades, the concept of "green economy" emerged from this pressure (Ciocoiu & Cicea, 2015).

In the current period, the specialists identified 2 major areas in which one can intervene to improve the situation, namely: energy production, with a focus on renewable energy (Montoya et. Al., 2014; Niblet et al., 2015), respectively consumption of the energy, in the context of sustainable development (Bojmec & Papler, 2011; Wang & Feng, 2003; Yesica Recalde et al., 2014).

In terms of energy consumption it should be noted that it has increased significantly in the last period, both in absolute and relative (per capita) terms. From the figure below it can be seen that the energy consumption per capita increased from a value of 1,337 tons of oil equivalent in the level of 1971 to a value of 1,922 tons of oil equivalent in the level of 2014.

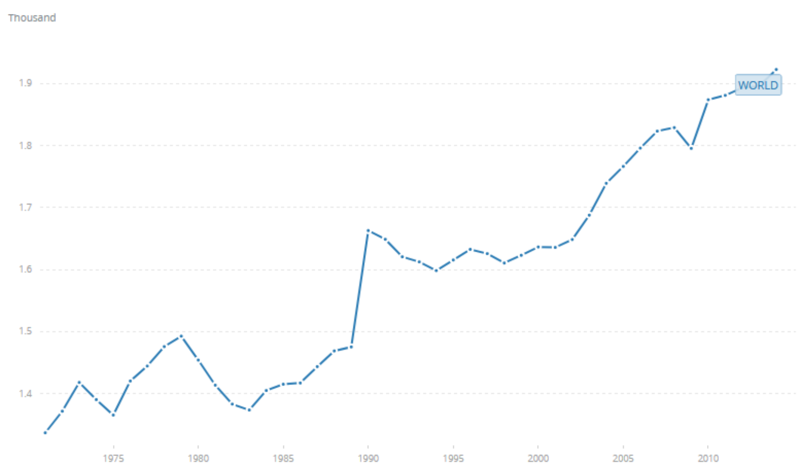

FIGURE 1- ENERGY USE OVER YEARS (IN KG OIL EQUIVALENT)
Source: World Bank, 2020a

If we also take into account the fact that the population has increased in this period from 3 billion in 1960 to 7.5 billion in 2017, we will have a clear picture of the explosion of energy consumption in the last 50 years.

Going further with the analysis, we find that the urban population increased significantly during the period analyzed (from a value of 1.01 billion in 1960 to a value of 4.196 billion in 2018), while the rural population registered a moderate growth (from 2.012 billion in 1960 to a value of 3.396 billion in 2018). A detailed situation of this indicator is presented in the figure below.

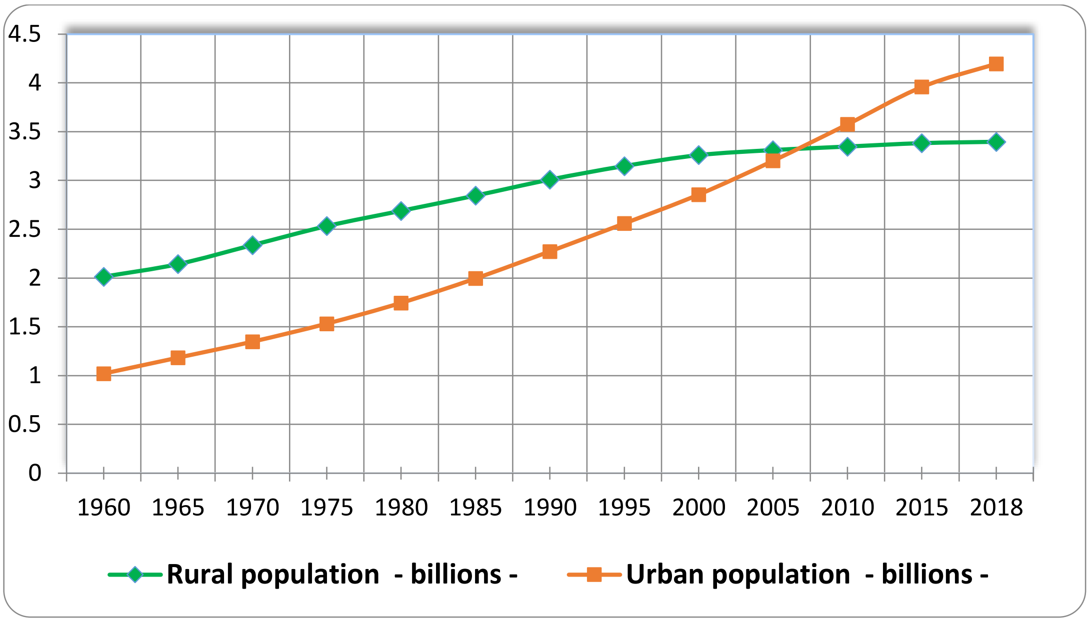

FIGURE 2 - URBAN AND RURAL POPULATION EVOLUTION BETWEEN 1960-2018
Source: Author own conception, based on World Bank, 2020b and 2020c

As can be seen from the figure above, the year 2005 represents the turning point, in which the urban population exceeded the rural population. Not coincidentally, energy consumption has increased significantly since this period (as can be seen from Figure 1).

Given these considerations, researchers have analyzed over time, in various forms (articles, reviews, proceedings papers, book chapters) the relationship between energy on the one hand and urban spaces / cities on the other hand. Of course, there are also some other important issues within urban area such as air pollution and crimes (Sabyasachi, 2018), healthcare systems and food security (Craveiro et al., 2016), water quality and environmental protection (De Figueirido et al., 2019), but the problem of energy is crucial because almost all of them depends on it.

In the present paper we propose to create a research agenda (analyzing scientific knowledge) in this field, based on a text mining approach. The present work continues a series of previous author's articles in the field of energy analysis in urban areas (Cicea et al., 2019a), as well as in the field of bibliometric analysis (Cicea et al., 2019b).

2. LITERATURE REVIEW

In the scientific literature, many authors have studied the issues between energy and urban areas, starting from energy conservation issues (Sugihara & Tsuji, 2008; Singh & Kumari, 2015), to renewable energy issues in the urban area (Barragan et al. , 2019), to those regarding energy efficiency (Karner et. Al., 2016) or to those regarding economic growth on account of energy (Marinescu & Cicea, 2011).

A brief history of the analysis of the interdependence between energy and urban areas / cities is presented in the Table 1.

TABLE 1 - SHORT HISTORY OF URBAN AREAS AND ENERGY RELATIONSHIP

Year	Author	Country	Topic
1998	Cammarata L. Fichera A. Forgia F. Marletta L	Italy	Study on the use of artificial intelligence and entropy law to improve energy efficiency in urban spaces
1999	Ercan Y.	Turkey	Develop an energy insurance model for industrial districts in the vicinity of urban spaces
2000	Balocco C. Grazzini G.	Italy	Use of thermodynamic indicators for planning energy consumption in urban spaces and for analyzing variants with low impact on the environment
2002	Tjusji K.	Japan	Identification and use of different multi-objective optimization models for planning future energy systems in urban spaces
2008	Sugihara &Tsuji	Japan	Energy conservation in urban agglomerations through the application of efficient measures to heat homes and water and also for energy consumption
2008	Katzenbach R. Vogler M. Waberseck T.	Germany	Use of thermal energy in urban areas to heat living spaces
2011	Ferrante A. Semprini G.	Italy	The need to modernize energy consumption systems for buildings in urban spaces
2015	Singh S. Kumari S.	India	The importance of increasing the efficiency in energy use / consumption in urban areas, starting from the use of biomass, extending the use of hydropower
2016	Karner K. Theissing M. Kienberger T.	Austria	Possibility of using industrial energy (resulting from different production processes) to cover the energy demand required by urban spaces (study conducted in 4 regions in Austria)
2017	Hukkalainen M. Virtanen M. Paiho S. Airaksinen M.	Finland	Use of an instrument developed in Finland (Kurke) based on which one can analyze the energy performance of urban development plans on the one hand, and on the other hand the reduction of CO2 emissions.
2018	Spinnraker E. Koschwitz D. Kirchmann F. Frisch J. Van Treeck C.	Germany	Use of WEB based computer applications to increase energy efficiency in urban spaces
2018	Moreno M. Escobedo M. Moreno A.	Spain	Bibliometric analysis based on the study of articles in the field to identify trends in renewable energy in urban areas, globally
2019	Barragan E. Zalamea E. Cepeda J. Gonzalez A.	Ecuador	Set of innovative technologies that can use urban resources to generate energy, based on the opinions of different experts from several countries.

Source: Author own conception

Analyzing these articles, we find that in the specialized literature there have been over time a variety of approaches to study the topic of energy in urban spaces (the use of specific computer programs, the questioning of groups of specialists from different countries, quantitative or qualitative approaches, etc.).

However, only one study (Moreno et al., 2018) used a bibliometric analysis to analyze the issue of renewable energy in the context of urban spaces.

In the following, starting from this analysis, we intend to expand the research area, based on a bibliometric analysis (combined with the text mining approach), to study the problem of energy (from any source) in the context of urban agglomerations / cities

3. RESEARCH METHOD

The chosen research method is a bibliometric analysis of the scientific literature, in order to create a research agenda, identifying the significant aspects for the specialists and illustrating future trends.

Specifically, bibliometric analysis involves studying scientific knowledge in a certain field (articles, reviews, conference proceedings, book chapters, etc.) based on statistical tools, in order to identify specific trends and patterns. In a close connection with bibliometric analysis, the paper proposes a text mining approach, in order to discover possible correlations and areas of interest regarding energy in urban spaces. The text mining approach involves the computer-assisted discovery of new information, based on the automatic extraction of data from different sources (Hearst, 2003).

The research methodology involves the following stages:

3.1. Identifying the source for collecting scientific output

Worldwide, there are a multitude of scientific production databases. The unanimous opinion of the specialists is that in the first two places, at a great distance from the others (by the number of indexed papers and the coverage area), are Scopus (provider - Elsevier) and Web of Science WoS (provider Clarivate Analytics).

Given that much of the scientific output is indexed both in the Scopus database and in WoS, in order to avoid redundancy in the analysis, we considered only one database. This was WoS, due to the higher number of indexed publications (approx. 100 millions, compared to approximately 70 millions for Scopus).

3.2. Identification of the scientific production that will be the object of the analysis

Based on the search engine of the Web of Science database, using the keywords "energy", "urban areas" and "cities" in the title of the publication, the initial database was created, which is the subject of the analysis. Subsequently, the elements that could create distortions in the analysis were eliminated (eg works that were written in a language other than English were eliminated; at the same time, only those works that represented articles, conference proceedings and book chapters were selected and the year 2020 was not taking into account, because it is not a complete year).

3.3. Analysis of scientific production based on a bibliometric approach of "text mining"

Based on the database created, the scientific production related to energy in urban areas was analyzed. The analysis was performed using the tools of the WoS database and also VOSViewer (van Eck & Waltman, 2011).

The analysis was carried out taking into account several dimensions - the scientific / editorial dimension, the geographical dimension, the temporal dimension and the lexical / semantic dimension. The main results are presented in the following section.

4. RESULTS AND DISCUSSION

Following the selection of the scientific production, 662 articles, conference proceedings or book chapters resulted that deal with energy issues in urban spaces. In the following we will analyze the scientific production starting from the dimensions specified above.

4.1. The scientific and editorial analysis

In detail, this number of publications covers a number of 25 WEB of Science categories, starting with "Energy & Fuels" (218 publications, representing 32.63%) and ending with "Mechanics" (14 publications, representing 2.1%). The categories that cover more than 10% of the total database are presented in the following table.

TABLE 2 - FREQUENCY OF PAPERS ACCORDING TO WOS CATEGORIES

No.	Web of Science category	Number of papers	%
1	Energy fuels	215	32.48
2	Environmental sciences	133	20.09
3	Green sustainable science technology	118	17.83
4	Environmental studies	89	13.44
5	Engineering electrical electronic	83	12.54
6	Construction building technology	73	11.03
7	Others (Engineering environmental, Urban studies, Engineering civil etc.)	-	-

Source: Autor own conception, based on WoS

It should be mentioned here that a paper can be classified into several categories of Web of Science, according to the journal in which it was published.

Going further with the analysis, the situation of the journals / conference proceedings with more than 10 published papers is presented in the figure below:

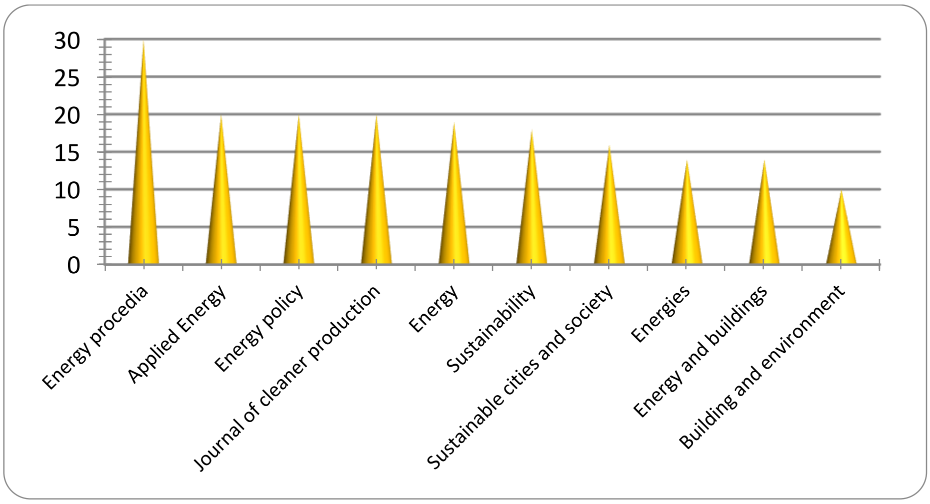

FIGURE 3 - TOP PUBLICATIONS WITH MINIMUM 10 PAPERS
Source: Author own conception, based on WoS

It should be mentioned that in the top of the publications with more than 10 papers there are only journals and no conference proceedings.

4.2. Geographical analysis

Regarding the geographical distribution of the works addressing energy in the context of urban areas, we can say that it is very diverse, totaling 77 countries. The situation of the countries with at least 20 papers (articles, conference proceedings or book chapters) that deal with this issue is presented in the graph below:

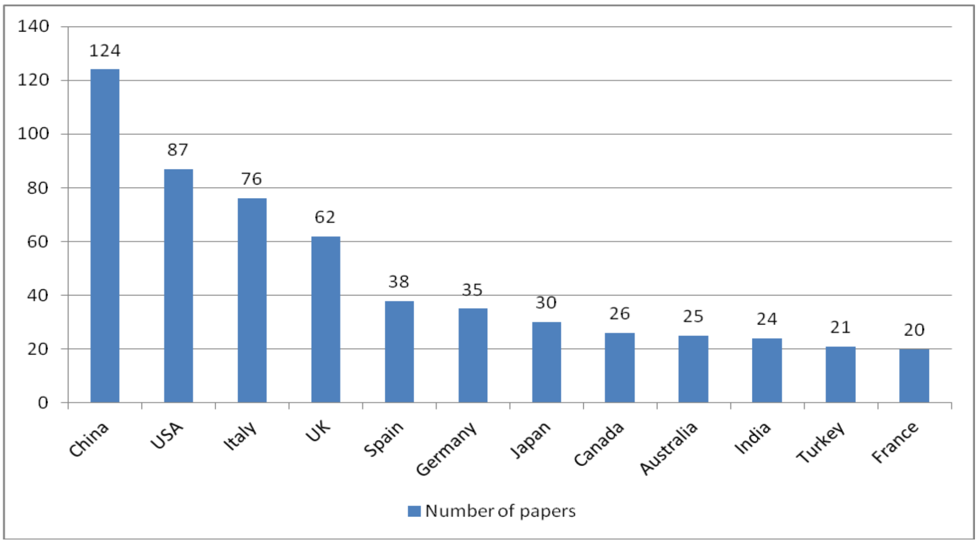

FIGURE 4 - TOP COUNTRIES ACCORDING TO THEIR FREQUENCY OF PAPERS
Source: Author own conception, based on WoS

The situation presented above is not so realistic, because it does not take into account the number of teachers (teachers) in each country (the more a country has a higher number of teachers, the higher the number of articles is expected - which does not mean a higher interest to analyze the respective field). Therefore, we consider more useful to present a map of the distribution of scientific production, weighted with the population of each country (Worldmeters, 2020).

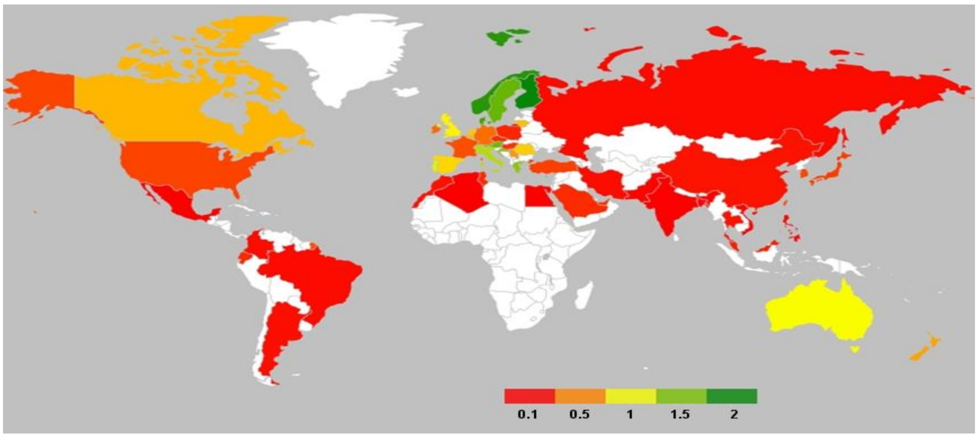

FIGURE 5 - GEOGRAPHIC DISTRIBUTION OF SCIENTIFIC PRODUCTION, PER 1.000.000 INHABITANTS
Source: Author own conception, based on WoS

As can be seen, the red areas show low values of scientific output per 1 million inhabitants (India - 0.017, Mexico - 0.015, Algeria - 0/012, Bangladesh - 0.012), while the green areas represent the higher values of scientific output per 1 million inhabitants (Finland - 1,985, Norway - 1,845, Denmark - 1,726, Cyprus - 1,626). Not surprisingly, the Nordic European countries have high values of this indicator, being recognized that these countries have a special concern for energy consumption in urban areas, with a high standard of living and a high human development index.

White area on the map means that have no scientific papers addressing the energy field in urban areas.

4.3. Temporal analysis

Regarding the temporal distribution, it is noted that the evolution was an increasing one, starting with 2 papers corresponding to 1976 and ending with 91 works corresponding to the year 2019. Moreover, this increase has been much more accentuated in the last period of time; if until the beginning of the third millennium, every year there were between 1 and 5 scientific papers per year (with the maximum value at the level of 1994), after 2000 there is an explosion of the number of articles, conference proceedings or book chapters dealing with energy issues. in urban spaces / cities. A detailed situation of this evolution is presented in the figure below:

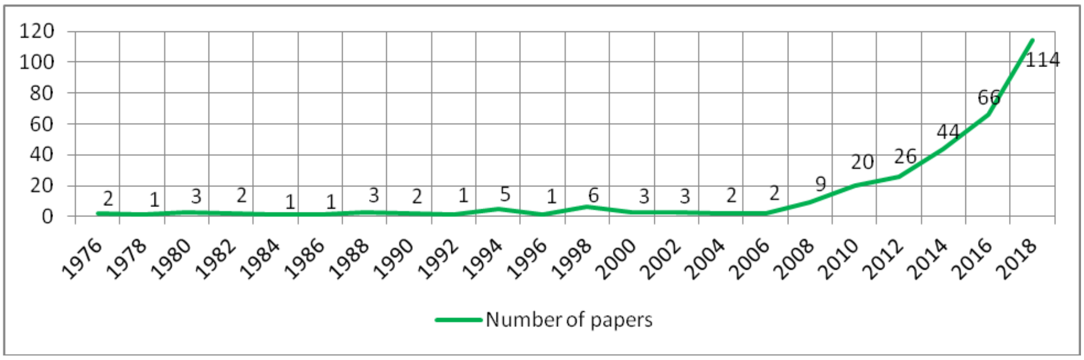

FIGURE 6 - TEMPORAL DISTRIBUTION OF SCIENTIFIC PRODUCTION, BETWEEN 1976 - 2018
Source: Author own conception, based on WoS

Undoubtedly, the explosion of the number of scientific papers registered after 2006 is due both to the increased interest of the researchers in this field and to the expansion of the Internet (and as a consequence, the number of indexed journal in different databases has increased).

TABLE 3 - KEYWORDS WITH A MINIMUM FREQUENCY OF 15

No	Keyword	Frequency	Links
1.	Consumption	52	29
2	Smart cities	48	22
3	Smart city	43	18
4	City	41	28
5	Energy efficiency	40	26
6	Systems	34	25
7	Management	34	28
8	Efficiency	33	29
9	Performance	32	29
10	Renewable energy	32	26
11	Sustainability	29	28
12	Energy	29	24
13	Energy consumption	29	22
14	China	28	21
15	Optimization	28	19
16	Emissions	27	23
17	Design	26	23
18	Buildings	26	25
19	Model	26	26
20	Cities	25	22
21	System	20	25
22	CO2 emissions	20	18
23	Policy	19	19
24	Climate change	19	20
25	Sustainable development	18	22
26	Climate-change	18	21
27	Impacts	17	23
28	Impact	17	17
29	Demand	16	23
30	Climate	16	19
31	Smart grid	16	16
32	Internet	16	8

Source: Autor analysis, based on VOSViewer

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4.4. Lexical / semantic analysis

The analysis involves the use of VOSViewer software, which analyzes the keywords in the scientific output analyzed, identifying similarities, patterns and interdependence relationships between the various analyzed variables.

The top of the keywords by their frequency is presented in the Table 3: The "Links" column, this represents the number of links a keyword has to another word. Thus, the keyword "consumption" has 29 links to other keywords.

In detail, the status of the links of the first 6 keywords according to the number of links (connections) with other keywords is presented in the Figure 7:

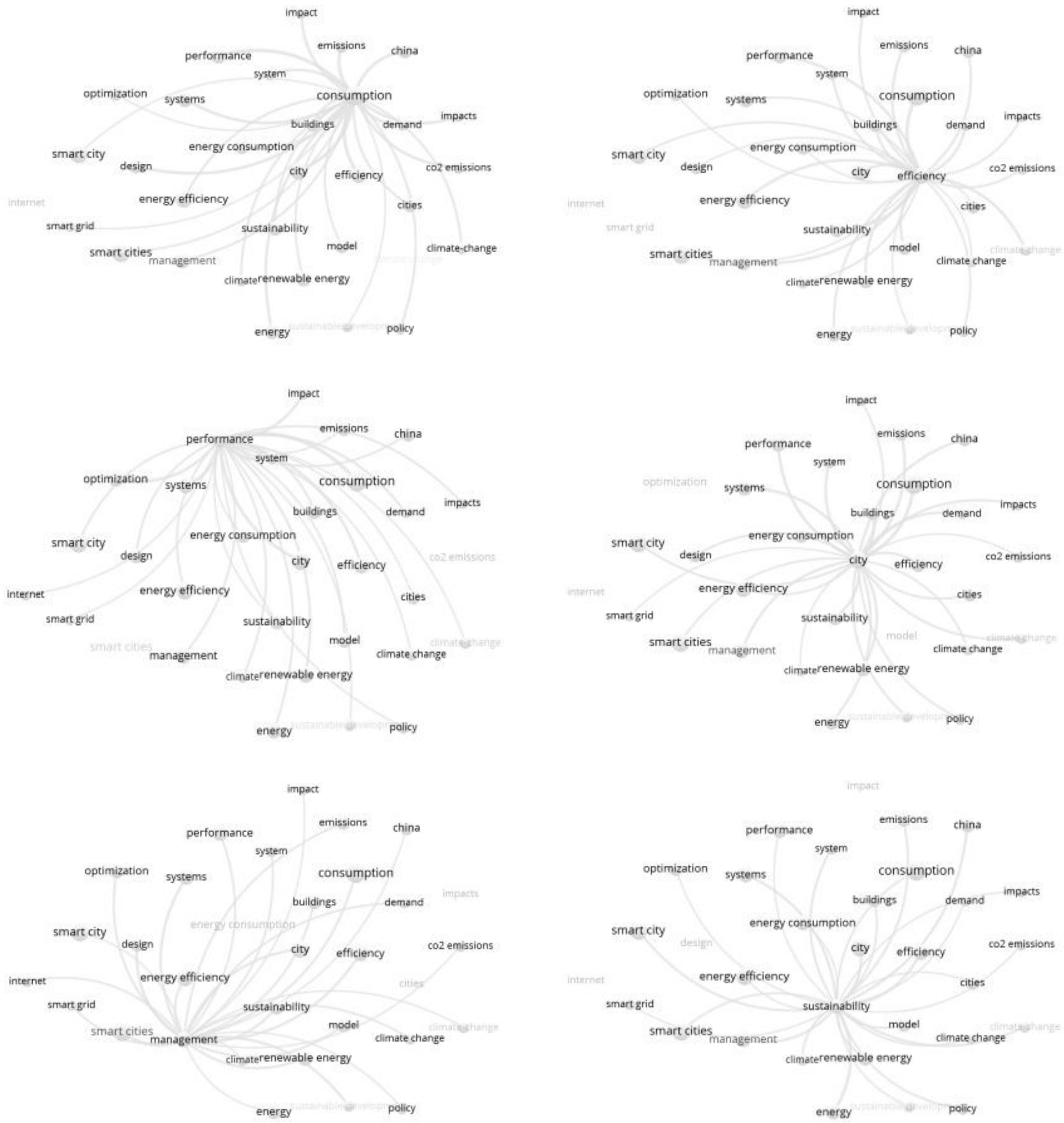

FIGURE 7 - TOP KEYWORDS, ACCORDING TO THEIR NUMBER OF LINKS
Source: Author own conception, based on VOSViewer

The six keywords with the highest number of links are "Consumption", "Efficiency", "Performance", "City", "Management" and "Sustainability". The number of links on each keyword is presented in the table no. 3.

Even more interesting is to analyze which are the strongest links of the six keywords presented above.

TABLE 4 - TOP 6 KEYWORDS ACCORDING TO THEIR NUMBER OF LINKS

No.	Keyword	Co-ocurrence keyword	Link strength	Link strength ratio
1.	Consumption	Performance	10	4.34
		City	9	
		Efficiency	9	
2.	Efficiency	Consumption	9	3.06
		Energy	5	
		Performance	5	
		Sustainability	5	
3.	Performance	Consumption	10	2.79
		Systems	7	
4.	City	Performance	6	3.46
		Buildings	6	
		Emissions	5	
5.	Management	Smart cities	8	2.60
		Design	5	
		Sustainable development	4	
6.	Sustainability	Energy	6	2.35
		City	5	
		Efficiency	5	

Source: Autor analysis, based on VOSViewer

As can be seen from the table above, the keyword "consumption" has the strongest connection with the keyword "performance", and at a short distance are the keywords "city" and "efficiency". Also, this keyword has the highest link strength ratio (according to the number of links and to link strength).

Looking at the table above it should be also mentioned the interdependence between "efficiency" and "consumption", "efficiency" and "energy", but also that between "management" and "smart cities".

5. CONCLUSIONS

Undoubtedly, the issue of energy in urban spaces (or cities) is extremely complex, in the context of contemporary economic reality. In this paper, the analysis has been carried out over a long period of time, more than 30 years (1976 - 2019).
The analysis carried out on the 662 articles considered (according to the procedural specifications mentioned above) highlighted that the widely used way of disseminating information is through journals

and less through conference proceedings or book chapter (62.71% of publications are of “article" type, 31.63% are of “conference proceedings” type and only 5.64% are of “book chapter” type.

Going further with the analysis, there is a particular concern for studying this interdependence among specialists, especially in Europe. More specifically, the countries that register a high number of articles on this topic per 1,000,000 inhabitants are Finland, Norway, Denmark, Cyprus, Sweden, Austria, Croatia, Greece, Switzerland, Italy and Portugal. Countries such as Japan (0.237), Russia (0.054) and Brazil (0.051) are on the low side of this indicator.

Regarding the temporal evolution of the scientific production, this has registered a significant increase since 2006, followed by a spectacular growth since 2010 (amid the exit from the global economic and financial crisis).

Finally, if we look at semantic and lexical analysis, we can see that energy issues in urban areas revolve around 3 major areas: the field of energy consumption (composed by keywords such as "consumption", "demand", "CO2 emissions", "efficiency", "performance", "China"); the field of smart city (consisting of keywords such as "smart city", "smart grid", "internet", "design", "systems", "management") and the field of environmental protection (consisting of keywords such as "renewable energy", "climate change", "sustainability", "sustainable development", "model").

We cannot conclude this analysis without presenting its main limits. One of these refers to the selected database of the articles for analysis, which cannot include all the scientific output in the analyzed field (in this case I choose the Web of Science database, instead of the Scopus database). This is based on the fact that the vast majority of specialists consider Web of Science database (WoS) to be the most widespread and most frequently used database for scientific production analysis (Yang et al, 2013). Another limitation concerns the analysis possibilities of the WoS platform and of the software (VOSViewer). From this point of view, it would be useful to see if the conclusions reached on the basis of the analysis of keywords and abstracts coincided with the conclusions resulting from the full text analysis of selected articles, conference proceedings and book chapters.

Based on these limitations, we appreciate that an in-depth analysis of the content of articles can be carried out in the future.

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