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A Scientometric Analysis of the Investigation of Biomass Gasification Environmental Impacts from 2001 to 2017

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ABSTRACT

To reduce the effects of climate change due to massive CO 2 emissions, renewable energy sources have been implemented; among them biomass through gasification. An important aspect of studying are the environmental impacts of this process. Therefore, a search was made in the database of the science website using keywords gasification environmental impact in the period from 2001 to 2017. When analyzing the 238 articles, an increasing tendency was observed in the publication of studies related to the ecological effects of the biomass gasification process. The United States, the United Kingdom, Italy, Spain and the People's Republic of China are the countries that have the most studies on the subject. The indicator total local citation score is used in order to identify the items that are the most cited, which indicates the degree of development they have in the study of the impacts of gasification.

Keywords: Gasification, Biomass, Environmental Impact
JEL Classifications: F64, Q40

1.INTRODUCTION

The two most important disadvantages of the extraction and burning of fossil fuels with energy effects and their effects on global climate change (Nguyen et al., 2013). Oil, natural gas, and coal are the primary fossil fuels; the first is used mostly in transportation and the second in the production of electrical energy. Studies have shown that there is a direct relationship between population and energy consumption (Cherubini and Strømman, 2011) (Tovar-Ospino et al., 2017); It is estimated that for the people of 2006 the demand for energy was 497 *EJ* ($497 \times 10^{18} J$) y by the year 2030 there is an increase in energy demand of 44%, that is, the consumption is 715 *EJ* ($715 \times 10^{18} J$) (Administration, 2008). To supply this elevation it is necessary to find other fuel sources such as oil sands and fracking (Administration, 2008) Not to mention the serious environmental effects that these entail (Figure 1).

Climate change is the most direct severe consequence of burning fossil fuels and fighting to avoid it is the motivation for the development and use of renewable energies, including bioenergy. Be understood as bioenergy all the energy that can be extracted from biomass (Cherubini and Strømman, 2011) (Nguyen et al., 2013); Biomass ranges from wood processing waste, agricultural waste and human and animal waste (Acar and Dincer, 2014). It is estimated that 3758×10^6 tons per year of residual biomass from crops, with an equivalent energy potential, are produced worldwide. A $69.9 \times 10^8 J$ (Lal, 2005). Table 1 shows the energy potential of the residual biomass produced in the USA and in the world, in addition to the illustration 1 shows the percentage of energy consumption consumed by biomass around the world. Gasification is one of the ways to use this energy potential. Gasification is defined as the process in which synthesis gas with a high content of hydrogen and low carbon dioxide content is obtained (Carpentieri et al., 2005). This gas can be used in several applications such as the generation of heat and/or electricity and to synthesize several products (Iribarren et al., 2014). For practical purposes of the implementation, it must be taken into account that the production potential of the gasification depends on the technology used for the process, the type of biomass used and the amount of air supplied as an oxidizing agent (Puy et al., 2010).

Biomass is a resource that does not contribute significantly to carbon dioxide emissions, the amount that is released is due to production, processing, and distribution and is small compared to the amount absorbed in the growth of crops, it is estimated that the production of carbon dioxide by bioenergy is 5% to 10% that produced by fossil fuels (Wang et al., 2013); additionally it does not emit nitrogen oxides nor sulfur dioxide as if it has fossil fuels (Koroneos et al., 2008). Despite all the benefits of the biomass gasification process, it should be noted that this presents particular problems that should be considered. The main disadvantage is that the problems of industrialized agriculture go to gasification, one of them is the eutrophication of bodies of water due to the use of chemical fertilizers (Kimming et al., 2011). Another considerable disadvantage is the production of waste such as tars and naphthalene and aromatic compounds that if not treated properly can harm the health of the environment (Susmozas et al., 2013).

The objective of this article is to analyze the behavior of Scientometrics in the development of studies and investigations of the environmental effects of the gasification of the residual biomass of crops included in the years 2001–2017.

2. METHODOLOGY

2.1. Objective of Study

The main objective of this study focuses on the analysis of the different bibliometric indicators related to the investigation of the environmental impacts of the biomass gasification with the articles obtained in Web of Science, which were then works in HitsCite to obtain the indicators for their subsequent analysis. The obtained articles were developed from 2001 to 2017.

This study allows us to define the information search equation that facilitates the achievement of the database to be analyzed by analyzing information obtained through a tool that allows us to visualize the information distributed by countries, published documents, authors and institutions and that finally identify publications with better research quality with higher total local citation score (TLCS) index in order to have a reference for future research.

2.2. Process

For the analysis of the information obtained and the generation of the results, it was necessary to follow the steps shown in Figure 2. The flowchart illustrates the four steps to follow for the scientometric study of the obtained scientific information.

In the first stage, the search equation is defined. This search equation is determined by the keywords that facilitate the obtaining of the information to be analyzed. The general theme of this article is the gasification process. To achieve the appropriate keywords, the keywordtool.io tool is used, where the search for gasification begins. Of all the resulting keyword combinations, gasification environmental impact is chosen.

Table 1: Energetic potential of crop residues produced in the USA and the world

Parameter	USA	World
Total crop residue (10^6 mg/year)	488	3758
Oil equivalent (10^6 barrels)	976	7560
Energy equivalent		
ExaJoules (10^{18} *J*)	9.1	69.9
Quads (10^{18} BTU)	8	60
10^{15} Kcal	1.5	11.3

Figure 1: Percentage of energy consumption from biomass around the world

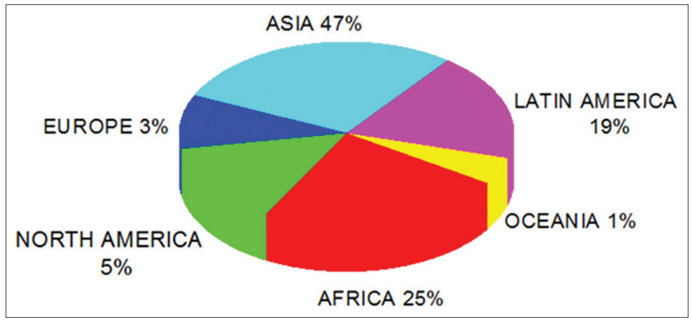
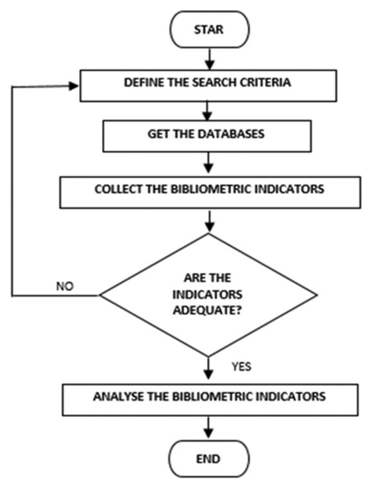


Figure 2: Flow chart for scientometric analysis



In the second stage, the previous keywords are used to search the articles for the scientometric analysis. For this, a metasearch called Web of Science is used that shows all the articles related to the keywords. This tool facilitates stage three since it provides a file that allows obtaining the bibliometric indicators.

In the third stage is where the tool called HitsCite is used, which facilitates the visualization of the biblio metric indicators, the input data for this is the file that the meta search generates. With this, you get the various indexes to analyze.

The fourth stage is where the analysis of all the results obtained with the HitsCite tool is performed. These studies are shown in graphs and tables presented in the results and discussion of them.

2.3. Population and Sample

The number of articles to be studied, or population is 238, divided into research articles, review of the state of the art, procedural articles and book chapter. The environmental impact of gasification, the articles were developed in the period comprised from 2001 to 2017.

3. RESULTS AND DISCUSSION

3.1. Type of Document and Language

In the 238 documents found it is observed that 193 are articles, this represents 81% of the total of the records. It was also evidenced that 36 of the documents reviews of state of the art, this is 15% of the total. Finally, there were eight procedural articles and one book chapter, which represents 3% and 1% of the total. In Figure 3 the summary of the above is observed.

With the above, he observes that the article is the most used medium for the dissemination of knowledge since it represents the highest percentage of documents developed. The total of the 238 papers was written in English to understand that this language is the most used in the scientific community.

3.2. Annual Research Production

As can be seen in Figure 4, there is an increasing trend in the production of articles related to research. The production went from 1 article published in 2001 to 31 published articles in the year 2017. It is noted that in 2002 there was no publication which is due to the lack of interest of the time in research related to the topic or the lack of experience. By the end of 2017, production can exceed 31 published articles.

It is observed that in the years 2008–2009 the production of articles went from 5 to 15 and in 2012–2013 it went from 16 to 32. This could be due to the rise in oil prices that occurred during the years 2008 and 2012 in June 2008 it reached a maximum of US $ 133.93/B and US $ 106.31/B in March 2012, in the WTI reference. In the reference, Brent had a maximum of 133.19 US $/B in July 2008 and 125.33 US $/B in March 2012. See illustration 5. With these price increases, the cost of energy production is higher. Therefore, the search for a cheaper source of energy increases, in this case, renewable energy. During these periods all renewable energies had a significant development. In the years starting in 2014, the production of articles has risen again due to the awareness of the need to lower the consumption of fossil fuels (Figure 5).

*The data to make this graph was taken from the official page of the organization of the petroleum exporting countries. WTI: American oil reference, BRENT: European oil reference

Table 2 shows the annual production with its respective percentage; it also indicates the TLCS of each year and its rate. In this case, TLCS indicates the times that they referenced the articles of that year.

3.3. Distribution by Countries

In total 48 countries have been investigating the environmental impacts of biomass gasification. In Figure 6 you can see the first ten states with the most publications related to the subject. The top 5 USA leads the list with 55 publications and closes China with 18. These countries are places with a high level of research and excellent economic development. These five states have been noted for their high energy consumption, mainly the USA and the People's Republic of China. Table 3 shows the values of the total number of articles published (recs) for the first ten countries, additionally indicates TLCS for each of these and at the end shows a TLCS/recs indicator. This indicator shows the quality of the articles published by the countries. It is observed that Spain has

Figure 3: Analysis of document types

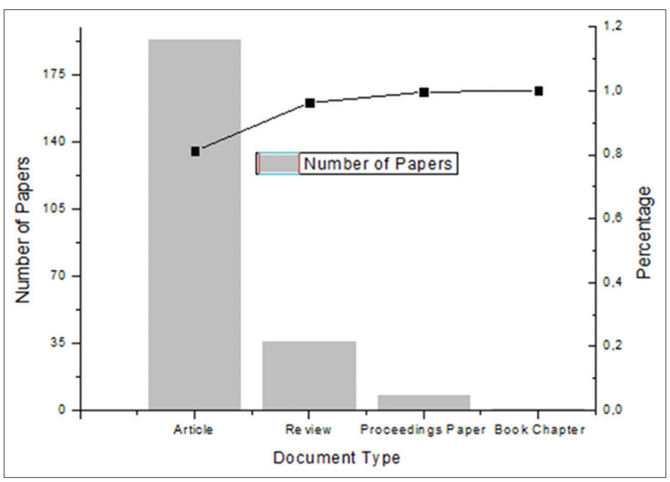


Figure 4: Annual production of articles in the years from 2001 to 2017

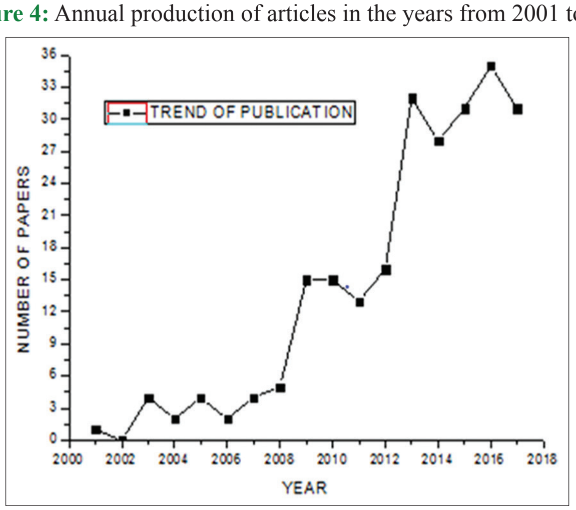


Figure 5: Oil prices from 2008 to 2017*

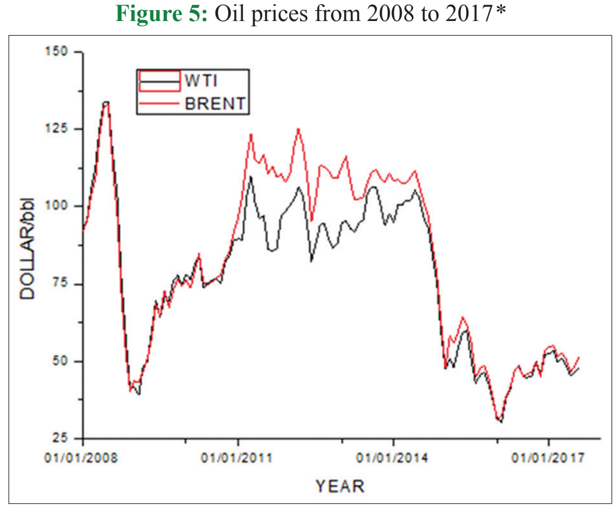


Figure 6: Annual production of the five countries with the highest production

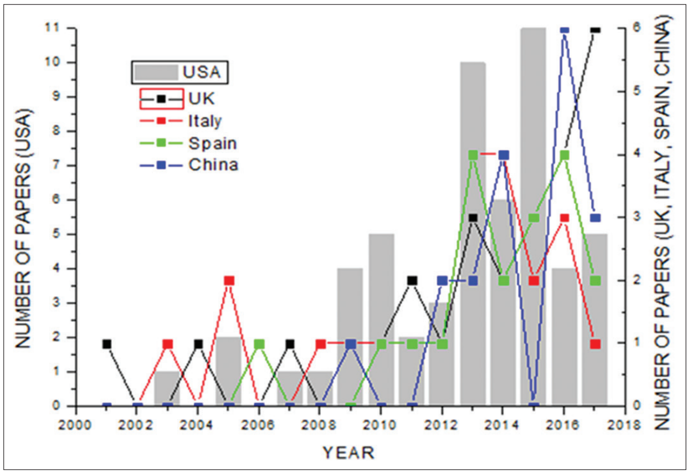


Table 2: Annual production and percentage

Publication year	Recs (%)	TLCS (%)
2001	1 (0.42)	1 (0.64)
2003	4 (1.68)	1 (0.64)
2004	2 (0.84)	1 (0.64)
2005	4 (1.68)	11 (7.05)
2006	2 (0.84)	1 (0.64)
2007	4 (1.68)	1 (0.64)
2008	5 (2.10)	12 (7.69)
2009	15 (6.30)	15 (9.62)
2010	15 (6.30)	17 (10.90)
2011	13 (5.46)	22 (14.10)
2012	16 (6.72)	10 (6.41)
2013	32 (13.45)	34 (21.79)
2014	28 (11.76)	17 (10.90)
2015	31 (13.03)	7 (4.49)
2016	35 (14.71)	5 (3.21)
2017	31 (13.03)	1 (0.64)

TLCS: Total local citation score

Table 3: Recs, TLCS y TLCS/recs of the top 10 countries

Country	Recs	TLCS	TLCS/recs
USA	55	42	0.764
UK	25	7	0.280
Italy	22	15	0.682
Spain	19	23	1.211
Peoples R China	18	5	0.278
Canada	14	9	0.643
Australia	11	3	0.273
France	10	1	0.100
Sweden	10	10	1.000
Denmark	8	6	0.750

TLCS: Total local citation score

the highest index since it was able to obtain more citations than the developed articles, thus showing the high quality of these. Figure 7 shows how the annual production from 2001 to 2017 of articles from the first five countries has been; it is observed that the USA had many periods of production higher than the other countries.

3.4. Distribution by Institutions

In total 312 institutions have published at least one document related to research on the environmental impacts of biomass gasification. For Table 4, ten organizations with the most publications were taken. For an institution to have several associated publications is a sample of its research level related to the subject. The institutions with the most publications are Juan Carlos University with six publications followed by IMDEA Energy Institute with 5 and North Caroline State University with 5.

Table 4: The ten institutions with the most publications

Institution	Recs	TLCS	Country
Rey Juan Carlos Univ	6	14	Spain
Inst IMDEA Energia	5	14	Spain
N Carolina State Univ	5	6	USA
Tech Univ Denmark	5	1	Denmark
Univ Toulouse	5	0	France
Swedish Univ Agr Sci	4	8	Sweden
Aristotle Univ Thessaloniki	3	8	Greece
Chalmers University of Technology	3	1	Sweden
Chinese Academy of Sciences	3	1	China
Cornell university	3	0	USA

TLCS: Total local citation score

Table 5: The ten journals with the most publications

Journal	Recs	TLCS
Journal of cleaner production	17	11
Applied energy	16	9
Renewable and sustainable energy reviews	15	9
International journal of hydrogen energy	14	22
Energy	13	3
Bioresource technology	10	14
Energy conversion and management	10	11
Biomass and bioenergy	8	8
Energy and fuels	7	0
Industrial and engineering chemistry research	7	1

TLCS: Total local citation score

In the previous table, it can be seen what was concluded in the last point. The first two institutions with the most extensive publications are Spanish, and their articles are also those cited in other articles.

3.5. Distribution by Journals

In the analysis of the 238 documents published, it is observed that all articles were published in 80 journals. Of these 80 journals are the ten that have more publications in which 117 articles were published, representing 49.2% of the total. The Journal of Cleaner Production, with 17 publications, makes it one of the most suitable for the publication of articles on this topic, it is an international and multidisciplinary journal focused on the research and practice of clean production, environment, and sustainability. Applied Energy is the second magazine with the most publications, a total of 16 articles. This journal provides space for the dissemination of information on innovation and research in the areas of conversion of energy, efficient use of energy as well as pollution mitigation and sustainable energy systems. The third magazine with the most publications, Renewable & Sustainable Energy Reviews with 15 in total, facilitates the communication of research related to renewable and sustainable energy. These three magazines are part of the ELSEVIER community (Table 5).

Figure 8 the annual production of the first five journals with the highest publication is observed, it is shown that the Journal of

Table 6: The 15 most cited articles

Paper	Author	TLCS
LCA of bioenergy systems: State of the art and future challenges	Cherubini and Stromman	10
LCA of an integrated biomass gasification combined cycle IBGCQ with CO2 removal	Carpentieri et al.	8
Comparative LCA of lignocellulosic ethanol production: Biochemical versus thermochemical conversion	Mu et al.	8
Life-cycle performance of indirect biomass gasification as a green alternative to steam methane reforming for hydrogen production	Susmozas et al.	7
Environmental and exergetic evaluation of hydrogen production via lignocellulosic biomass gasification	Iribarren et al.	6
Hydrogen production via biomass gasification - A LCA approach	Koroneos et al.	5
An economic and environmental comparison of a biochemical and a thermochemical lignocellulosic ethanol conversion processes	Foust et al.	5
LCA of biomass-based combined heat and power plants	Guest et al.	5
Sustainable design and synthesis of hydrocarbon biorefinery via gasification pathway: Integrated LCA and technoeconomic analysis with multiobjective superstructure optimization	Wang et al.	5
Environmental assessment of gasification technology for biomass conversion to energy in comparison with other alternatives: The case of wheat straw	Nguyen et al.	5
LCA of Bioethanol from Pine Residues via Indirect Biomass Gasification to Mixed Alcohols	Daystar	4
LCA of hydrogen production from biomass gasification. Evaluation of different Spanish feedstocks	Moreno and Dufour	4
Future fuel supply systems for organic production based on Fischer-Tropsch diesel and dimethyl ether from on-farm-grown biomass	Ahlgren et al.	3
An energy analysis of ethanol from cellulosic feedstock-corn stover	Luo et al.	3
Environmental assessment of post-consumer wood and forest residues gasification: The case study of Barcelona metropolitan area	Puy et al.	3

LCA: Life cycle assessment, TLCS: Total local citation score

Figure 7: Top 10 of the countries with the most publications

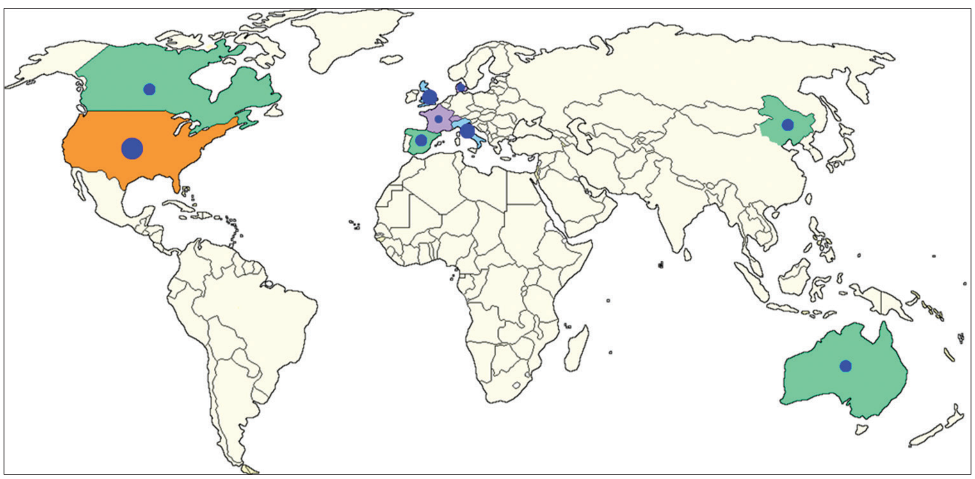
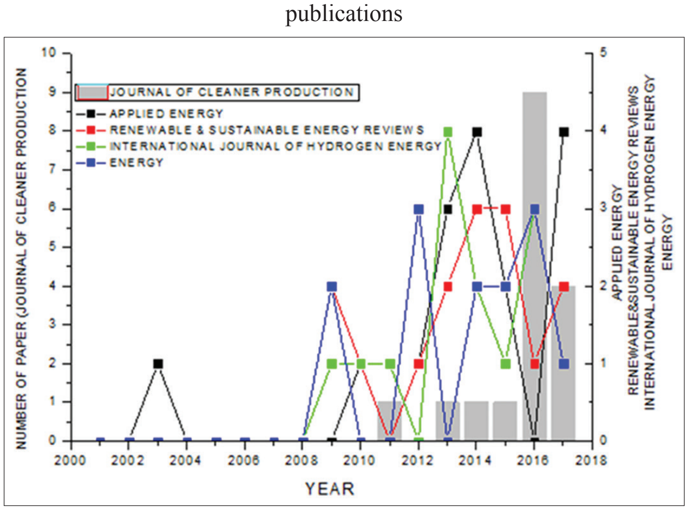


Figure 8: Annual production of the five journals with the most publications



Cleaner Production has the most publications and is the one that published the most articles in all the periods.

3.6. Authors with More Publications

For this part of the analysis, it is necessary to know the number of articles published by the author and the times that these were citations in other works. Table 7 shows the ten authors with their respective number of publications and TLCS. Dufour is the author who has more publications and TLCS, which indicates that he has more experience working on the subject and his articles have excellent quality for being the most cited of all.

3.7. Relevant Articles

Table 6 shows the 15 most cited articles with their respective author evidenced in TLCS, this evidence that the content of them is of vital importance for the development of research on the environmental impacts of biomass gasification.

Figure 9: Relationship between the 10 most cited articles

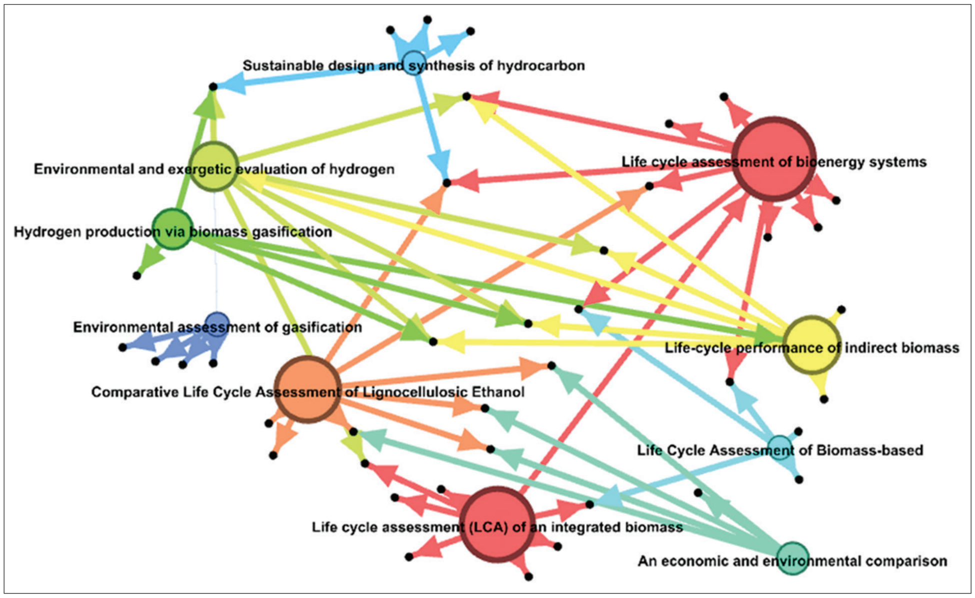


Table 7: Authors with more publications

Author	Recs	TLCS
Dufour	7	18
Dincer	6	7
Iribarren et al.	6	14
Baky	4	8
Balat	4	4
Bernesson S	4	8
Cherubini F	4	15
Daystar	4	4
Gonzalez	4	6
Hansson	4	8

TLCS: Total local citation score

In Figure 9 it can be seen that each node represents an article. The nodes with greater size are the articles that were more cited; the small nodes are the ones that they quoted. The size of the node depends on the times it was mentioned. The arrows indicate the meaning of the citation, that is, they leave the cited article and arrive at the article that made the citation.

4. CONCLUSIONS

It is observed that the investigation of the environmental effects of biomass gasification in the early years of the 2000s was the last but the last to reach the previous generation of side effects in the last year climate. The industrialized countries like EE., UU. Which are the major emitters of greenhouse gases, are those that are more related to the effects of gasification. This is due to the international actions that have been taken to mitigate the effects of climate change. It is also observed that in countries where its economy depends on oil exploitation, such as Saudi Arabia and Iran, studies on this problem.

The "practices" in Spain have a high degree of quality with respect to genes from other countries, which makes this nation a reference for future research related to the environmental effects of biomass gasification.

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