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## Article

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#### Provided in Cooperation with:

International Journal of Energy Economics and Policy (IJEPP)

*Reference:* Estêvão, João (2021). Toward the Paris agreement implementation impact on electricity sector : the emerging reality. In: International Journal of Energy Economics and Policy 11 (1), S. 1 - 8.

<https://www.econjournals.com/index.php/ijeep/article/download/10276/5548>.

doi:10.32479/ijeep.10276.

This Version is available at:

<http://hdl.handle.net/11159/8088>

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## Toward the Paris Agreement Implementation Impact on Electricity Sector: The Emerging Reality

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Received: 13 July 2020

Accepted: 04 October 2020

DOI: <https://doi.org/10.32479/ijeep.10276>

### ABSTRACT

The signing of the Paris Agreement has created a new avenue of research because it sets out a global challenge to tackle climate change by limiting global warming.<sup>1</sup> The topic is of growing interest involving investigators from different scientific areas, with the focus being on the increase in the consumption of renewable energies and, consequently, on the reduction of carbon dioxide emissions. From the research, most studies use simulation models to verify whether the goals set out in the Agreement are achievable. This paper presents an analytical review of the publications in order to assess the attention and awareness focused on the Paris Agreement and, specifically, the electricity sector. For this purpose, our study uses a bibliometric analysis considering authors, the types of documents, the title of the sources, the year of publication, the institutions, the languages, the countries of origin, and related concepts. In conclusion, the study's most frequent terms are "Paris Agreement", "carbon", "climate change" and "renewable energy". It also concludes that the topic is of growing interest within academia. The results of this paper provide to energy researchers a relevant overview of the tendencies and scope of the Paris Agreement.

**Keywords:** Paris Agreement, Electricity, Bibliometric analysis

**JEL Classifications:** K32, O13, Q43, Q48, Q56

### 1. INTRODUCTION

There is a growing awareness that human actions are affecting life on the planet. This is reflected in the climatic changes seen in recent times. In order not to further compromise future generations, it is necessary that the new generations have a more relevant role in relation to decarbonization and energy use (Monyei and Oladeji, 2019) and an effort must be made to find less polluting forms of energy production (Forero et al., 2019), as it is clear that electricity is one of the world's major assets.

With the goal of safeguarding the future for coming generations, on October 24<sup>th</sup>, 2014 European Union (EU) member states signed the 2030 Climate and Energy Policy Framework. This agreement was the basis the following year for the signing of the Paris Agreement. After 2014, several other agreements have

been signed by numerous countries; in particular, the United Nations Agreement in 2015. However, the agreement between the EU member states is the most ambitious, showing the greatest commitment to reach the goals set in 2014.

The 5<sup>th</sup> Assessment Report of the IPCC gives a board view of the key economic sectors affected by the Paris Agreement such as energy, water services, transports, tourism, insurance and financial services, among others. The IPCC report demonstrates the impacts of climate change on development by making a global and sectoral assessment (Gomez-Echeverri, 2018). As mention by (Arto et al., 2016) the use energy is associated to the level of the human development index (HDI) thus being a key economic sector in the degree of development of a country. The energy sector (in particular the fossil energy) will be suffer a change due the climate policies, i.e., the switch to a production of clean energies. On the other hand, clean energies could be boosted by

<sup>1</sup> [https://ec.europa.eu/clima/policies/international/negotiations/paris\\_en](https://ec.europa.eu/clima/policies/international/negotiations/paris_en)

the established goals of higher energy consumption. The Paris Agreement is important milestone has given rise to a new avenue for the publication of research related to the Paris Agreement and its links to markets and companies in the electricity sector. According to (Sattler et al., 2020) the decarbonization of the electricity sector is one of the cost-effective ways to reduce of CO<sub>2</sub>. Hence the reason for analyzing the research that has been conducted in the electricity area since then.

This work analyzes the characteristics of publications related to the Paris Agreement and electricity topics. Using a bibliometric analysis, a descriptive review has been carried out to identify the main topics, authors, the types of documents, the title of the sources, the publications over time, the institutions, and the country of origin of these publications.

## 2. TOWARDS THE PARIS AGREEMENT

Climate change has become an increasingly pressing issue on the political agenda around the world. This is not only due to environmental sustainability matters, but also because sustainability has an economic and financial impact. These economic-financial issues are mainly those that generate less agreement among the different countries. Whereas developed and major polluting countries are aware that they should care about climate change and adopt measures that promote greater environmental and economic sustainability (Cooper, 2016), the poorest countries feel that these impositions are causing a greater gap between rich and poor nations. According to Diffenbaugh and Burke (2019), wealthy countries benefit more from the activities that cause global warming than poor countries. This process of recognizing the need to take measures that have a real impact on the planet's sustainability has been gradual, with the first major agreement being signed by UN countries, the Kyoto Agreement, in 1997. The signatories of the Agreement introduce, for the first time, quantitative and achievable targets that can reduce carbon dioxide emissions by each country in order to combat climate change (Wei et al., 2015). The Kyoto Agreement also introduced a sustainable solidarity mechanism in which those countries that were required to reduce their levels of carbon dioxide emissions could help developing countries by implementing appropriate projects in those countries, and thus be compensated for not achieving the reduction established in their own countries. The Kyoto Agreement established that industrialized countries should reduce their carbon dioxide emissions by 5.2% compared to 1990 levels. Taking carbon dioxide emissions into account has opened the door for countries to negotiate with each other, thereby creating a new regulated emissions trading market (Thomas, 2014).

Although the Kyoto Agreement was the first major attempt to address the problems of climate change, since 1995 UN countries have been meeting regularly, and these meetings have been called Convention of the Parties (CoP). For the first time, UN countries sought to reach consensus on how to mitigate climate change (Rocha and Santos, 2018). Despite the countries' commitment, the results obtained were limited, as countries such as the United States did not ratify the Agreement, while Canada withdrew from it when it saw

that it was not going to meet the established goals. Additionally, the Agreement also failed to engage citizens and companies.

Consensuses are hard to reach among the UN's 190 countries. For that reason, the EU has shown greater flexibility (consensus between 28 countries is easier than 195), commitment, and granted greater freedom in terms of the timing of actions to be taken. To reach an agreement, they know they must acknowledge the singularities of each country.

In order to reach this Agreement, which aims at achieving sustainable development, there have been regular CoPs since 1995 designed to reach an agreement that is attainable by all countries, and at the same time there is a commitment to achieve it. According to article 2, 1a) (United Nations, 2015) the objective is "holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels". Countries have submitted comprehensive national action plans on climate change to reduce their emissions. Governments have agreed to report every five years on their contribution to setting more ambitious targets, reporting to other governments and the public on their performance in achieving their goals to ensure transparency and oversight. The EU and other developed countries will continue to provide climate change funding to help developing countries reduce emissions and build resilience to climate change impacts.

In the aftermath of the Paris Agreement, the countries agreed that responsibilities and capabilities are not the same for all countries. Nevertheless, the target should be shared across the board. Therefore, each country's specific conditions should be taken into consideration, as well as their differing responsibilities and obligations (Falconí et al., 2019). Each country has the freedom and responsibility to define policies and measures to combat climate change. These policies and measures can be at the level of transport, buildings and efficiency, or agriculture, for example. In terms of transport, conditions can be created for reducing transport needs by promoting public transport or avoiding transport based on fossil fuels. From the point of view of buildings, support can be provided for promoting building refurbishment and alterations by introducing more efficient heating and cooling systems. At agricultural level, too, encouragement can be given to more eco-friendly agricultural practices, for example, while taking into consideration that policies and measures should not be in isolation, but adopted in a holistic way (Köppl and Schleicher, 2018). The implementation of these policies may have a tax component, but also a strong technological side (Falconí et al. 2019), which requires investments. As a result of the regular meetings to discuss and prevent climate change and promote sustainable development, in 2014 the countries established a goal that the temperature of the planet should not rise by more than 2°C, and preferably not surpass 1.5°C by 2030. To achieve this target, the increase in the consumption of renewables should increase by at least 27%; the reduction in carbon dioxide emissions should be in the order of 40% compared to 1990 levels, and there should be an increase in energy efficiency to mitigate climate change (European Council, 2014).

In this way, the European Union thus wants to show that it is a world leader in combating climate change, seeking to work towards cleaner, safer, more accessible and more sustainable energy, and this has been endorsed by the European Commission as one of its main objectives. As stated by Moedas, (2018), these objectives can be verified by strengthening the research on clean energies that can be verified in the areas of renewable energies, energy storage, increasing electric mobility, and decarbonizing existing buildings. To achieve these goals, funding for projects related to climate change involving the energy, transport, environment and/or agriculture sectors has been made available through the Horizon 2020 program. The energy sector, in particular the electricity, will be transformed by climate policy because the production of electricity through fossil fuels will be forced to reduce and will emerge the production of electricity by renewable sources. Political measures have been taken to foster the use of renewable energies such as feed-in tariffs, tenders and tax incentives that has a positive effects (Kilinc-Ata, 2016).

### 3. DATA COLLECTION AND SELECTION CRITERIA

This study uses a bibliometric analysis to advance the knowledge related to publications associated with the Paris Agreement and the electricity sector. The bibliometric analysis consists of the collection, treatment and quantitative analysis of scientific output (Verbeek et al., 2002), and according to Petticrew and Roberts (2006) allows mapping out areas of uncertainty and identifying what has been done in a particular field of research and what can be done. The data are retrieved from the Web of Science (WoS) and Scopus databases because they are the principal and largest collections of articles and publishers at global level (Dangelico, 2016; Alves and Mariano, 2018; Ertz and Leblanc-Proulx, 2018; Ochoa et al., 2019).

The topic of electricity is vast and has been studied from different perspectives. However, with the signing of the Paris Agreement, a new avenue of investigation emerged that could be explored by academics. The Paris Agreement is often associated solely with climate change, as reflected by the growing number of publications on this topic (Haunschild et al., 2016). Nevertheless, the Agreement goes beyond climate change, addressing several sectors of the economy, with one of them being electricity. The search strategy is thus to combine the keywords of the “Paris Agreement” and “Electricity”, following the rationale of Haunschild et al. (2016), with a view to delimiting the scope of this work. These two keywords (Paris Agreement and electricity) cover this work’s major themes, and so all the explorations it contains begin with their combination. A special mention should be made of the fact that all research fields were considered, therefore considering all the works in the different areas that refer to these two keywords.

Based on the rationale of Martin and Assenov, (2012), the search involved the intersection of the publications that interconnected the Paris Agreement and the electricity to books and/or chapters of books, articles in scientific journals, conferences papers and reviews in journals. Masters or doctoral theses were not included,

nor were government and not-for-profit organization reports, working papers and magazine publications because they were not available in the databases used. Likewise, when research could not be authenticated, it was regrettably excluded.

In addition to the keywords, another filter that limited the scope of the searches was that only abstracts written in English were considered (Liu et al., 2019), because according to Bocanegra-valle research, (2014) publishing in English guarantees both a large number of readers and a focus of research and opportunities for international cooperation and recognition (Alves and Mariano, 2018). In order to delimit this analysis of the existing scientific output on these subjects, it was decided to consider the publications issued between 2015 and 2018, in the last case because it’s last full year available. It is important to study the literature produced because it shows whether the Agreement is having recognized implications or not and can give clues to future addenda to the Agreement, or on the contrary, to its abandonment.

### 4. DATA ANALYSIS AND RESULTS

A possible way to evaluate whether the research is up to date is by analyzing the temporal distribution of publications. Table 1 presents the evolution of the several types of publications.

According to Figure 1, out of the 210 publications, 155 are articles in journals, 16 are review, 9 are books and book chapters and 30 are conference papers.

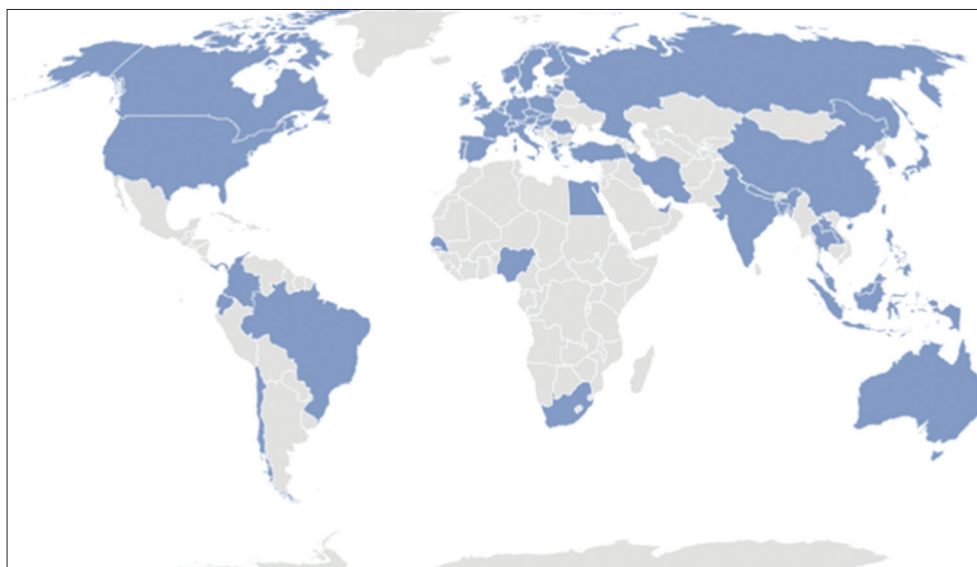
Following the rationale of Hansen, Liu, and Morrison (2019), another bibliometric analysis involves the number of publications in peer-reviewed journals. In the case of the 155 articles, they were published in journals covering different scientific areas. Considering the three scientific journals (Energy Policy, Applied Energy, and Energies) with more publications in these topic (Table 2), it should also be pointed out that they involve major fields (Energy, Environmental Science, and Engineering), which indicates the presence of a common read in several areas (Table 3). It’s also important to mention that 43 of the documents are classified as “other” in journals from fields of study such as Law, Urban Studies, Geography, and Applied Physics, among others, which gives a degree of transversal importance in the academy

As regards the articles’ keywords, there are 157 different keywords in the 210 documents, with an average of 8.8 keywords per document. The most popular keywords are “Climate Change”, “Greenhouse Gases”, “Carbon Dioxide”, “Emission Control”, and the expression “Gas Emissions” (Table 4).

**Table 1: Evolution of scientific publications (2016-2019)**

	Articles	Book	Book Chapter	Review	Conference paper	Total
2016	4	0	0	1	0	5
2017	27	0	2	1	6	36
2018	50	2	4	7	13	76
2019	74	0	1	7	11	93
Total	155	2	7	16	30	210

**Figure 1:** Nationality of the author’s institutions. In blue the countries of author’s institutions, in grey the countries without author’s institutions.



**Table 2: Top journals by number of articles published between 2016 and 2019**

Journal	2016	2017	2018	2019	Total
Energy Policy	0	6	3	8	17
Applied Energy	0	4	5	7	16
Energies	0	1	2	7	10
Journal of Clean Production	0	0	3	5	8
Environmental Research Letters	0	0	3	4	7
Renewable and Sustainable Energies Review	0	0	2	4	6
Sustainability Switzerland	1	2	1	2	6
Joule	0	1	1	3	5
Climate Policy	1	0	0	2	3
Energy Economics	0	0	0	3	3
International Journal Of Greenhouse Gas Control	0	0	1	2	3
Philosophical Transactions Of The Royal Society: A Mathematical Physical And Engineering Sciences	0	0	3	0	3

**Table 3: Documents by subject**

Documents by subject area	
Energy	133
Environmental Science	109
Engineering	72
Social Sciences	32
Economics, Econometric and Finance	17
Mathematics	17
Business, Management and Accounting	14
Earth and Planetary Sciences	13
Physics and Astronomy	12
Computer Science	10
Others	43

**Table 4: Top ten keywords in the articles**

Keywords	Total
Climate changes	70
Greenhouse gases	57
Carbon dioxide	49
Emission Control	45
Gas Emissions	36
Electricity Generation	34
Energy Policy	34
Carbon Emission	32
Fossil Fuels	32
Global Warming	32

Through bibliometric analysis it was also possible to understand which topics are most covered by the journals that publish the most about Paris Agreement and Electricity. Based on the ranking of the top five scientific journals by number of publications, Table 5 shows the most researched topics. The most common keywords are Climate Change and Greenhouse Gases, and they are common to several journals. Energy Policy, Fossil Fuels, Electricity, Electricity Generation and International have several appearances in this top five journals.

Another aspect to take in considerations is the main authors that published on the Paris Agreement in terms of electricity for the

period 2015-2019. According to Table 6, the number of authors is diverse and small, albeit suggesting some specialization in the topic, with five or more publications on the subject. The main contributors are Dmitrii Bogdanov and Christian Breyer, with seven and six publications each in journals and ten and nine if consider all types of documents used in the sample.

Another way to analyze whether the publication of an article is relevant to the area is through the number of citations where a higher number of citation indicates a higher impact (Liu et al., 2019; Penela et al., 2019). In order to capture each publication’s



**Table 5: Top keywords in the main journals in terms of the number of publications**

Journal	Top Keywords 1 <sup>st</sup>	Total	Top Keywords 2 <sup>nd</sup>	Total	Top Keywords 3 <sup>rd</sup>	Total
Energy Policy	Climate Change	11	Energy Policy	10	Electricity Generation	8
Applied Energy	Climate Change	8	Electricity	7	International Agreement	7
Energies	Greenhouse Gases	5	Gas Emissions	4	Energy Management	3
Journal of Clean Production	Climate Change	4	Greenhouse Gases	4	Carbon Dioxide	3
Environmental Research Letters	Fossil Fuels	8	Climate Change	6	Carbon Emission	4

**Table 6: Top authors by articles and documents (2016-2019)**

Author	Nº. Articles	Author	Nº. of Documents
Brayer, C.	7	Brayer, C.	10
Bogdanov, D.	6	Bogdanov, D.	9
Mac Dowell, N.	5	Mac Dowell, N.	5
Daggash, H.	4	Daggash, H.	4
Guillén-Gosálbez, G.	3	Child, M.	4
Krey, V.	3	Jaguer-Waldau, A.	4
Aghahosseini,	2	Frafan, J.	3
Akimoto, K.	2	Fasihi, M.	3
Algunaibet, I.	2	Guillén-Gosálbez, G.	3
Burandt, T.	2	Hanak, D.	3

impact, the number of individual citations was retrieved from Scopus, as shown in Table 7. The most cited article is “100% Clean and Renewable Wind, Water, and Sunlight All-Sector Energy Roadmaps for 139 Countries of the World” by Mark Jacobson and their colleagues which was published in 2017 in the journal “Joule” and has been cited 160 times. This article develops roadmaps to transform the all-purpose energy infrastructures (electricity, transportation, heating/cooling, industry, agriculture/forestry/fishing) of 139 countries to ones powered by wind, water, and sunlight. The second most cited article is by Christian Breyer and Dmitrii Bogdanov with 58 citations until the end of 2019, focusing in a model based on hourly resolution for an entire year, the world structured in 145 regions, high spatial resolution of the input renewable energy resource data, and transition steps of 5-year periods. Most studies of journals in the sample are based on simulation models, but no studies have been developed where is exposed that has already been changed due the implementation of the Agreement.

A further aspect to consider is the geographic spread of the journals that publish articles on the Paris Agreement. The location of the authors’ institutions indicates whether a subject attracts interest in global research; whether there is a geographic spread or a concentration in certain countries. According to this research, there are up to fifty seven different nationalities of affiliation, with a predominance of Europe-based authors with about half of the publications, although all the continents are represented (Figure 1).

The Paris Agreement has created interest among researchers from around the world, because every continent has at least one instance of research with at least one publication. When the articles in co-authorship are considered, European authors are responsible for around 58% of the publications, but every continent has researchers pursuing these topics. Another highlight is that 59 of the 155 articles published are co-authored with researchers from other countries, reflecting a concern for the internationalization of research, and thereby enriching it. This fact can be interpreted

has a sharing of knowledge. By contrast, only fourteen articles have a single author, while the others have coauthors. In the case of books and chapters, the sample has two cases of publications by single individuals, and all the other publications have more than one author.

To analyze the impact of academia to these topics its interesting check the distributions by affiliations. Table 8 presents the authors’ affiliation to a research center or university. According to the table, universities in the United Kingdom have the highest output related to the topic. Other countries such as Germany, the Netherlands, and Japan have a relative weight in global terms.

It is worth mentioning that agencies that have sought to encourage research on certain topics are sometimes linked to universities and/or research centers through funding. Table 9 presents the funding agencies that contribute to the development of studies related to these subjects. Government agencies such as the Engineering and Physical Sciences Research Council (EPSRC), Tekes, European Union, and the National Natural Science Foundation of China often subsidize projects in partnership with universities to seek an independence perspective from academic researchers.

## 5. DISCUSSION

The results of the analysis of publications on this topic show a year-on-year increase. The year 2019 accounts for 44% of the publications. Articles are the main contributors, with 73% of the publications. The figure also shows an increase in articles, and between 2016 and 2019 this growth was almost twenty times higher than the initial analysis period. They show a big increase in 2019 compared to 2016, when four articles were published compared to 2019, when 74 were published. Regarding the three journals with the most publications (Energy Policy, Applied Energy and Energies), it can be inferred from their titles that they involve different core areas (Energy, Environmental Science and Engineering), indicating a presence of a topic that is mainstream to several areas of study and can be explored in different ways.

The dedicated publications cover two predominant areas, energy and the environment. These main areas reveal that 2019 was the year with the most publications in the period under analysis. Almost all the other areas record a strong growth of results in 2019 over previous years, except for the economics area, which was similar between 2017 and 2018. These results may reflect researchers’ perception of a new line of research that has emerged with the Paris Agreement. In terms of articles, the number has been growing from year to year; however, the journals with the most publications are Energy Policy, Applied Energy and Energies. The

**Table 7: Top 10 most cited academic papers on timeshare by Scopus at 31 of December 2019**

Title	Pub. Year	Citations	Authors
100% Clean and Renewable Wind, Water, and Sunlight All-Sector Energy Roadmaps for 139 Countries of the World	2017	160	Jacobson, M., Delucchi, M., Bauer, Z., Goodman, S., Chapman, W., Cameron, M., Bozonnat, C., Chobadi, L., Clonts, H., Enevoldsen, P., Erwin, J., Fobi, S., Goldstrom, O., Hennessy, E., Liu, J., Lo, J., Meyer, C., Morris, S., Moy, K., O'Neill, P., Petkov, I., Redfern, S., Schucker, R., Sontag, M. & Wang, J.
Solar photovoltaics demand for the global energy transition in the power sector	2018	58	Breyer, C., Bogdanov, D., Aghahosseini, A., Gulagi, A., Child, M., Oyewo, A., Farfan, J., Sadovskaia, K. & Vainikka, P.
Photovoltaics and wind status in the European Union after the Paris Agreement	2018	45	Lacal Arantegui, R., Jäger-Waldau, A.
A review of technology and policy deep decarbonization pathway options for making energy-intensive industry production consistent with the Paris Agreement	2018	36	Bataille, C., Åhman, M., Neuhoﬀ, K., Nilsson, L., Fishedick, M., Lechtenböhmer, S., Solano-Rodriguez, B., Denis-Ryan, A., Stiebert, S., Waisman, H., Sartor, O., & Rahbar, S.
The need for national deep decarbonization pathways for effective climate policy	2016	33	Bataille, C., Waisman, H., Colombier, M., Segafredo, L., Williams, J. & Jotzo, F.
Can Australia power the energy-hungry asia with renewable energy?	2017	28	Gulagi, A., Bogdanov, D., Fasihi, M. & Breyer, C.
A review of developments in technologies and research that have had a direct measurable impact on sustainability considering the Paris agreement on climate change	2017	25	Foley, A., Smyth, B.M., Pukšec, T., Markovska, N., Duić, N.
Climate Impacts in Europe Under +1.5°C Global Warming	2018	24	Jacob, D., Kotova, L., Teichmann, C., Sobolowski, S., Vautard, R., Donnelly, C., Koutroulis, A., Grillakis, M., Tسانis, I., Damm, A., Sakalli, A. & van Vliet, M.
Snapshot of photovoltaics-March 2017	2017	23	Jäger-Waldau, A.
Pathways limiting warming to 1.5°C: A tale of turning around in no time?	2018	22	Kriegler, E., Luderer, G., Bauer, N., Baumstark, L., Fujimori, S., Popp, A., Rogelj, J., Strefer, J., & Van Vuuren, D.

**Table 8: List of researchers' main affiliations (2016-2019)**

Affiliation by articles	N° Publications	Affiliation by documents	N° Publications
UCL	11	UCL	12
Imperial College London	10	Imperial College London	10
Leppennrannan	7	Leppennrannan	10
Technical University of Berlin	6	Technical University of Berlin	7
International Institute for Applied Studies	6	International Institute for Applied Studies	7
Potsdam Institut	6	Potsdam Institut	6
Tshingua University	5	Utrecht University	5
ETH Zurich	5	ETH Zurich	5
National Institute for Environmental Studies of Japan	5	National Institute for Environmental Studies of Japan	5
Utrecht University	4	Stanford university	5

**Table 9: List of the main affiliations of researchers and funding agencies (2016-2019)**

Funding Sponsor	N° Documents
Engineering and Physical Sciences Research Council	12
Tekes	8
Natural Environment Research Council	7
National Natural Science Foundation of China	6
European Commission	5
Agence Nationale de la Recherche	3
Bundesministerium für Bildung und Forschung	3
Deutsche Bundesstiftung Umwelt	3
Deutsche Forschungsgemeinschaft	3
Energimyndigheten	3
European Regional Development Fund	3
Horizon 2020 Framework Programme	3
National Eye Research Centre	3

Regarding the articles' keywords, they reflect each one's content, so based on Table 2 there are three keywords with more frequent citations in the articles under analysis. Climate Changes itself stands out, such as (Obregón et al., 2019), but then the keywords that relate to the Paris Agreement's objectives and goals appear, such as combating greenhouse gases to ensure the average global temperature increases by no more than 2°C or ideally 1.5°C, by reducing emissions through the increased consumption of renewable energy such is suggested by Forero et al., (2019).

Regarding the number of citations, the top articles in terms of citations address the goals set by the Paris Agreement and how to achieve them by 2030 or 2050, according to the timeframe set in an attempt to combat global climate change. Most of them focus on renewable energy issues through simulation models, setting consumption targets and seeking sustainable development in accordance with the principles of Glavas and Mish (2015), which are social development, economic development, and sustainable development; in other words, the triple bottom line approach.

difference between these journals and the others can be explained by the fact that the former already published on these topics in 2017 while the other journals had almost no publications, which only started to appear in 2018.

The Paris Agreement was signed by UN countries in 2015, and after that the academic community has paid it increasing attention, with the majority of publications emerging from research conducted by at least one author from a European institution. This can be explained by the fact the EU has paid special attention to climate change, and in 2014 signed an agreement similar to this with the goal of combating climate change and thereby alerting the European scientific community to these issues. Furthermore, academia in the US and Asian countries such as China and Japan have also paid considerable attention to this subject. A reflection of its multidisciplinary nature is measured by the circumstance of the increasing number of publications with co-authors from different nationalities, giving different perspectives to the research.

Based on Table 6, it is worth highlighting the clearly leading role in research on the topics of the Paris Agreement and electricity played by European universities compared to the rest of the world. A special mention should be made of universities in London, with a combined total of 17 publications. In a similar vein, the same is true for research institutions funding these topics, where there is a predominance of European agencies, with emphasis on the EU as the main funding agency for publications in the period mentioned.

## 6. CONCLUSIONS AND POLICY IMPLICATIONS

This study uses a bibliometric analysis to advance the state-of-the-art related to publications associated with the Paris Agreement and the electricity sector with a trend for conducting research on the Agreement. First, 44% of the publications identified were published in 2019, and second, articles in journals account for nearly 73% of the sample.

Although the Agreement was signed in 2015, these topics have gained increasing interest over time in academia, bringing a new emerging reality. The Paris Agreement and electricity are studied from different perspectives and various research fields, and the results show that the areas of most interest in these topics are energy and the environment. A reflection of this interest is the fact that the keywords most cited apart from Paris Agreement are carbon, climate change, and renewable. These keywords are consistent with the Agreement's main objectives.

The main journals are from different fields of research (Energy Policy, Applied Energy And Energies), and the results show a predominance of keywords related to climate changes, greenhouse gases. There is an increased use of renewable energy, particularly photovoltaic, because the cost of production is relatively lower than other renewable energies. This increase was fostered by the Paris Agreement.

It is also perceptible that as the years go by there are more and more publications on these subjects and how they affect society at large. It is worth mentioning that countries in Europe are the ones that have more authors and more publications on these subjects, perhaps reflecting their greater commitment to the goals established in the Agreement. However, there are no authors with

numerous publications yet, and the two most prolific ones have ten publications each. This reflects a new field of research in which scholars have much to explore. The study also shows that the behaviors need to be changed in order to achieve the goals set with the Agreement in order to have greater acceptance by all stakeholders because the simulation models. This is demonstrated by simulation models where it is necessary to increase renewable energy consumption and reduce carbon dioxide emissions to achieve the set objectives and this way combat the climate change and achieve a sustainable development.

This study has made a number of important contributions to this new and global energy subfield, namely, the Paris Agreement. First, it contributes by collecting the academic publications related to this recent issue, and by serving as the first-ever compilation of journals and chapters in books on energy and the Paris Agreement. It then uses this information to further study and understand the trends that are emerging in the energy sector related to the Paris Agreement and this way contributes for a sustainable development.

Another important contribution is related to the identification of key authors and institutions in this topic. These data are valuable as they provide opportunities for exchange and collaboration among researchers to advance this body of literature, which is in considerable need of further research.

The research also contributes to the perception that is necessary implement measures to achieve the goals of the Paris Agreement because several studies show the way of reach the goals set, through simulation models, but few studies have been published about the results of that measures in the real world by countries and/or companies on the planet. It will be interesting to see in companies or countries changes imposed by the Agreement and how they were implemented.

Finally, this study shows that these subjects can be explored from different perspectives, with different fields of research interest. This is revealed by the fact that there are publications from different areas and by the increase in the number of journals starting to pay attention to this subject.

It's a study that will help policy making and influencing social actors to take a position on the Paris agreement.

As in any study, this work also has its limitations. The first limitation is due to the language used for the research/paper selection. Following common practice (Bocanegra-Valle, 2014), the study has considered only those studies published in English. Thus, works in other languages, and which may be relevant to these topics, were not selected or analyzed, so a more complete analysis is pending (Liu et al., 2019). Like the results obtained by Gatto and Drago (2020) it is not expected that the results will change significantly.

Similarly, the choice of just two databases, the WoS and the Scopus, means there are other works that were not taken into consideration. A further study could be conducted based on other



bibliometric sources to verify whether there is a similar tendency to that presented here of a greater number of authors and works in Europe. There is also a need to verify whether the works not indexed in the databases used here have an equal dispersion of scientific areas on this topic.

Since this is a recent topic, more research should emerge over the coming years, and in five years from now a similar study should be conducted and the results compared.

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