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Article

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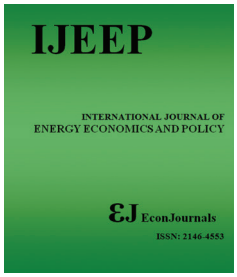

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Applied Bibliometric in the Advancement of Solar Energy Research

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ABSTRACT

Bibliometrics has proven to be an efficient method for quantitative research on the statistical behavior of academic production, which allows analyzing existing data and documents to resolve trends in specific research fields. Considering the database downloaded from Web of Science, with the help of Hitscite and VOSviewer data analysis tool and Microsoft Excel table, 7,259 publications related to solar energy research from 2010 to 2020 were obtained. The purpose of this research work is to apply bibliometric analysis methods to the development of scientific research on solar energy, as an important part of renewable energies, to evaluate its progress in the last decades and to describe these trends. The results showed that since 2015, research on solar energy has increased, especially in countries such as the United States and China, due to the Paris treaties where the goal is that the average temperature of the earth by the year 2100 does not exceed 1.5°C. Since greenhouse gases are the cause of the greatest impact of the increase in global temperature, it is expected that researchers will focus on harnessing green energy and take a step further to reduce fossil fuels.

Keywords: Bibliometric, Solar Energy, Greenhouse Effect
JEL Classification: Q42

1. INTRODUCTION

Solar energy is one of the many current tools for renewable energy generation, due to its positive impact to the environment by contributing to the mitigation of the effects of fossil fuels (Đurašković et al., 2021). Thanks to bibliometrics, a method of quantitative analysis for scientific consumption and production (Shehatta et al., 2019), in the last 5 years research on solar energies has increased for research scientists (Calderon et al., 2020). Due to technological and research advances, the amount of captured energy increased, applying solar tracking techniques, solar radiation collection tilt angle refinement, solar spectrum splitting techniques and global diffuse radiation collection (Apostoleris et al., 2016), (Borhanazad et al., 2013).

Solar panels can present a maximum solar generation taking into account that they remain perpendicular to the sun's radiation as long as possible (Mangiante et al., 2020), (Oh et al., 2019). Another factor that maximizes the performance of solar panels is the application of high-efficiency multi-junction cells (Silva-Rodriguez, 2008), (Philipps et al., 2015) which take advantage of the direct light spectrum by capturing diffuse light on cloudy days (Wilkins et al., 2017). Most researchers focus on solar tracking (Edward and Dewi, 2019), as the performance of a mobile panel over a fixed panel in the same area creates 30-45 % higher efficiency (Rizk and Chaiko, 2008). Investigations of multi-junction cells for solar panels present an efficiency between 40 and 45%. (Chekalin et al., 2022).

The studies of solar energy as a transcendent mechanism in the change to renewable or green energies, through a bibliometric research provides an integration of quantitative data on publication trends, which can be focused on indicators such as keywords, article titles, year of release, among others.

Figure 1: Data download process

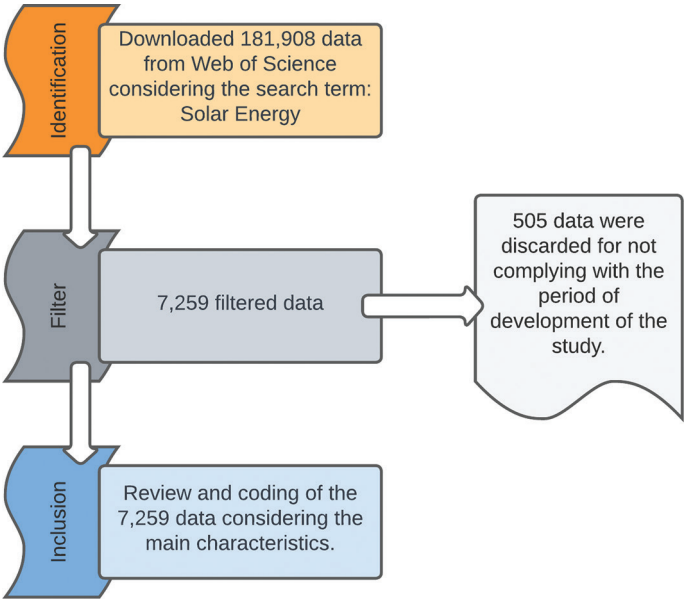
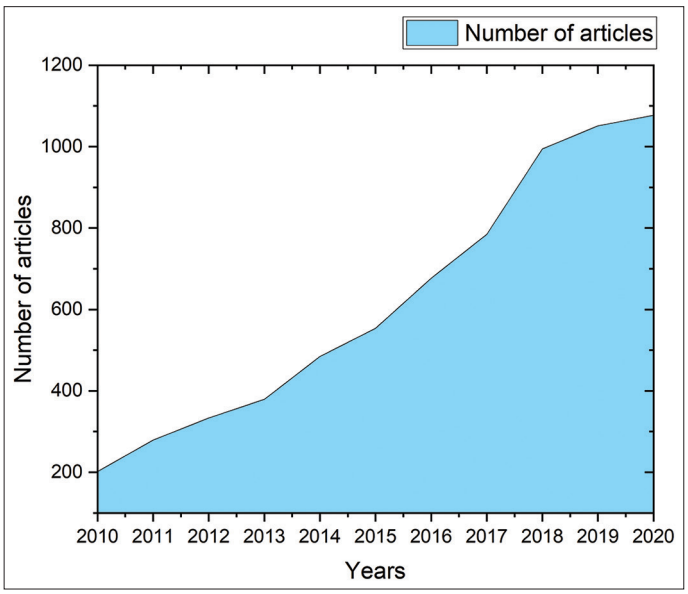


Figure 2: Number of annualized publications



This work focuses on applying bibliometric analysis methods to the development of solar energy as an important part of renewable energies, in order to evaluate its progress in the last decades and describe these trends. It focuses on the years 2010-2020 taking into account countries, institutions, language, type of document, year of publication and authors, in order to investigate the state of research on the development of solar energy. These results help to understand the development of research on solar energy, where it is focused, and which countries and researchers contribute the most to this research.

2. METHODOLOGY

This research work was conducted based on the methodological principles of bibliometrics (Donthu et al., 2021). By downloading data using Web of Science tools, the search terms were the words "Solar Energy," "Solar Panel" and "Photovoltaic Solar," which were filtered by the years of publication (between 2010 and the present) and the title of the articles.

Figure 3: Number of publications per country

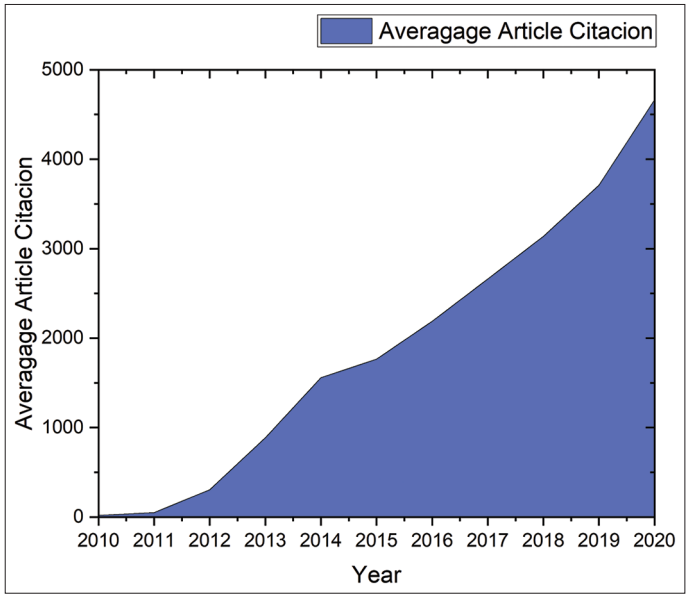


Figure 4: Type of document

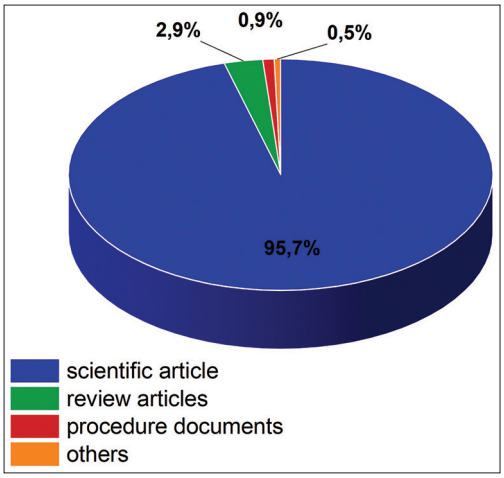


Figure 5: Number of publications per country

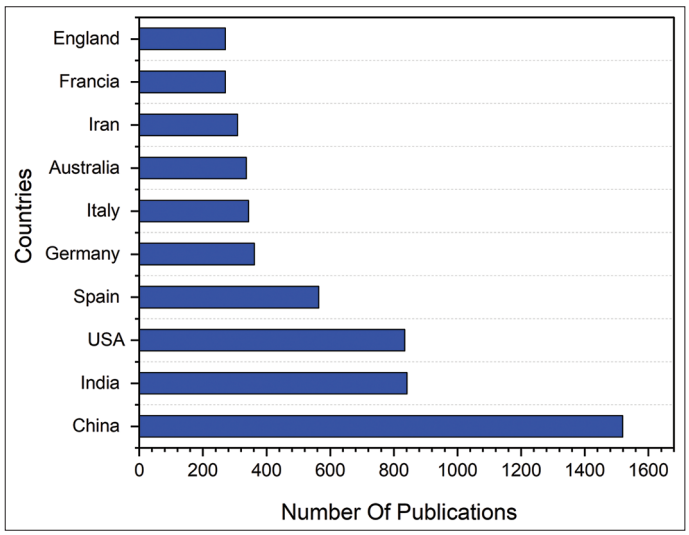


Figure 6: Interaction between countries

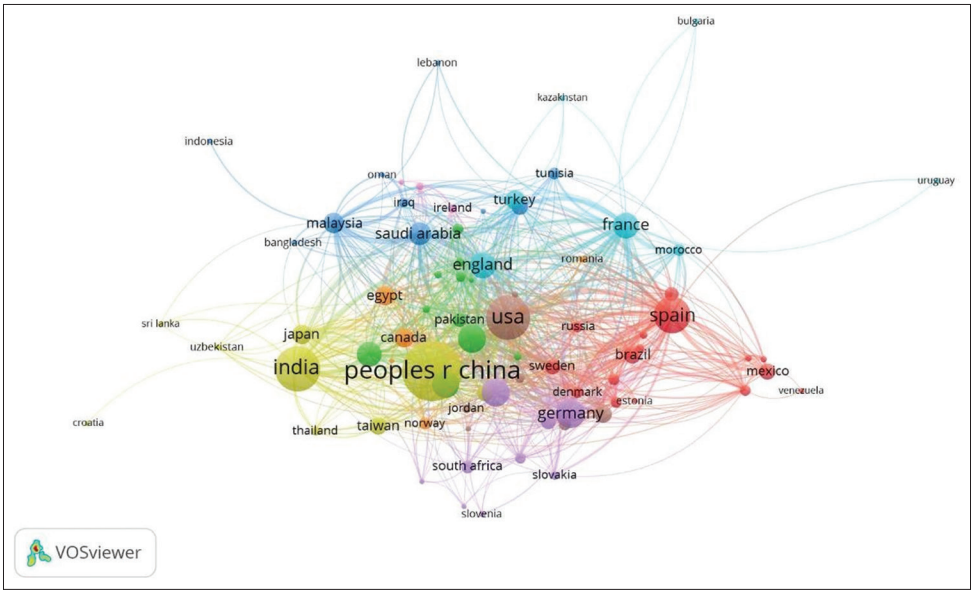
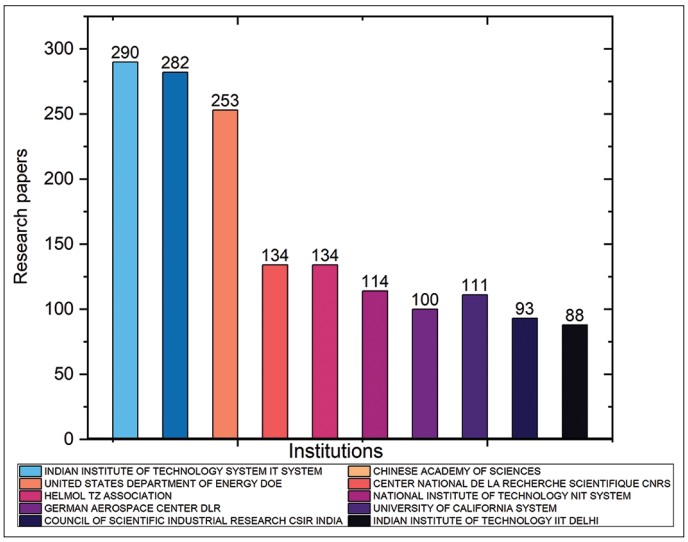


Figure 7: Institutions highlighted in research papers



Using the Histcite tool (program for bibliometric analysis), the previously downloaded data were processed in order to organize and process them into authors, years of publication, type of documents, language and country. Subsequently, they were tabulated and graphed with Microsoft Excel, to analyze in more detail the trends and hierarchies of the research and its authors in recent periods. Likewise, the influence of the most representative authors in the last decade is studied, as well as the countries that contribute most to the improvement of research, given the importance of the development of research activities. In the development of this work, the data collected through the databases (Moral-Muñoz et al., 2020) were analyzed.

The sample population of this research consists of 7,259 records, taking into account the data filter applied to discard publications of the current year 2021 (Figure 1). Among the most outstanding records are articles, procedural documents and editorial material, where 95% of the total records downloaded from 2010 to 2020 are articles, taking into account the search criterion "Solar Energy" in the title.

Finally, for the study, the bibliometric indicators provided by HitstCite are taken and processed using tools such as VOSviewer.

3. RESULTS

The analysis of published articles on solar energy research from 2010 to 2020 was carried out. Among the parameters to be analyzed are: publications by number of years, type of documents, countries most prominent in publications and language of the publications.

3.1. Number of Publications per Year

An analysis was made of the articles published according to each year since 2010. The annual publications of this type of scientific document increase every year (Figure 2). The increase in articles from 2015 onwards reflects a great interest in researchers in alternative solutions to the consumption of fossil fuels in this case, solar energy.

A possible determining factor to encourage the production of scientific papers on solar energy may have been the opportunities provided by the governments of each country to develop these energies in their territories. It should be noted that solar energy has a higher power density compared to other renewable sources, which has influenced the development of research during the last 5 years.

As can be seen in Figure 3, the number of citations is in line with the increase in the number of articles published and their development, which indicates a high level of interest in the research carried out.

3.2. Types of Documents

The 7,259 data were downloaded from the Web of Science database. Among the documents highlighted by the researchers are: in first place the scientific article with 6,948 documents (95.71%), followed by review articles with 213 documents (2.939%) and procedural documents with 63 documents (0.867%). All these give a total of 7,224 which represents 98.6% of the most influential

Figure 8: Interaction between institutions.

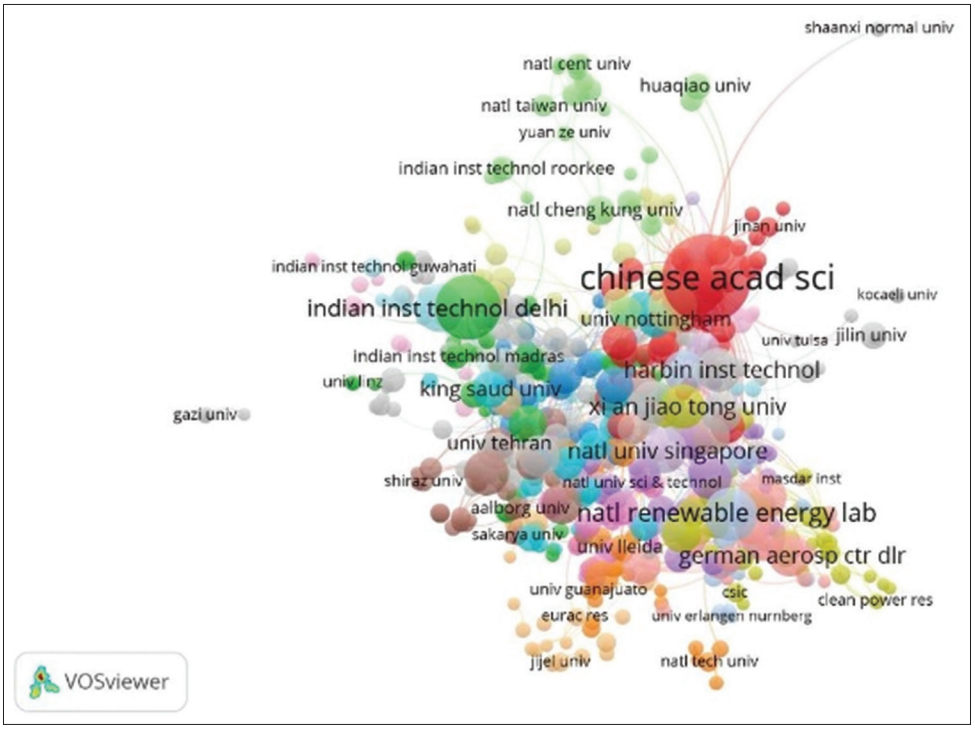
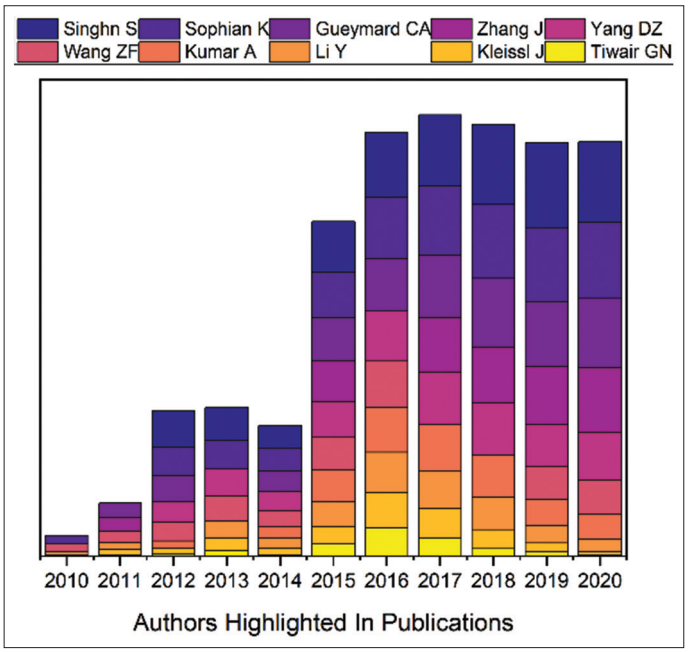


Figure 9: Authors highlighted in publications



documents at present. Other documents such as editorial material and letters, data documents represent less than 0.4867% (Figure 4).

Due to the influence on the different types of documents, the number of publications can be related to the total number of global citations. This relationship shows that when there are a large number of publications in a type of document, this will possibly be the most cited by researchers; however, the information given in these documents is still more reliable and important for the research community and this is demonstrated in the form of citations.

3.3. Number of Publications per Country

Solar energy is researched, according to the Web of Science platform, in 114 countries from 2010 to 2020. Figure 5 shows the leading countries in research development; these are led by China with 26.83%, followed by India and the United States with 14.86% and 14.70% respectively, totaling 53.39% of the total research carried out. Countries such as Spain, Germany, Italy, Australia, Iran, France and England represent 43.62%.

An analysis was carried out using the VOSviewer tool to identify the relationship between these countries. It was found that countries such as China, India and the United States are widely related in the development of research activities (Figure 6).

3.4. Language and the Most Important Institutions

English was the language most used in the research documents, occupying 99% of these: it should be noted that this language is adopted by the entire community because it is a universal language. Only one document is written in Danish.

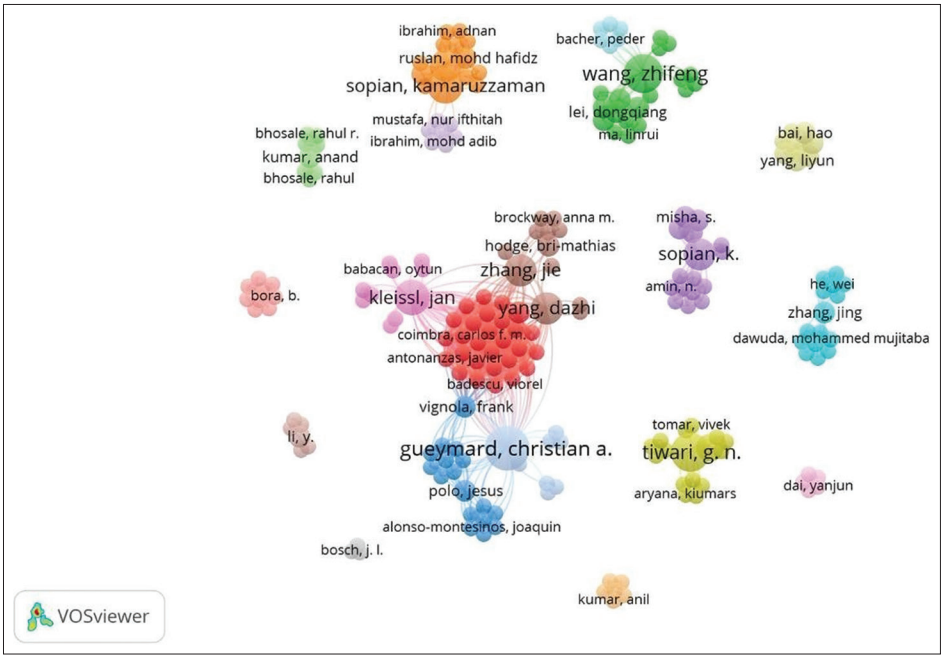
On the other hand, the Indian Institute of Systems Technology ranks first with 290 research papers. This is followed by the Chinese Academy of Sciences with 282 papers and the U.S. Department of Energy DOE with 153 (Figure 7).

The Chinese Academy of Sciences stood out for its relationship with other institutions, followed by the Indian Institute of Technological Systems (Figure 8).

3.5. Number of Publications per Author

After analyzing the data obtained, it was found that Tiwari GN are among the leading authors in the development of research on solar energy or Solar Energy (Figure 9).

Figure 10: Interactions between authors



Referring to the relationships between authors, it can be seen in the Figure 10, that Gueymard Christian has a greater interaction with other authors such as Kleissl Jan.

4. CONCLUSIONS

This research work shows the performance of research on solar energy from 2010 to the present, all this thanks to the data obtained from the Web of Science database, which allowed categorizing the information by type of documents, publications by year, by country and language.

The results obtained show an annual increase, so it can be concluded that the field of solar energy is gaining more and more interest and strength every day. As of the date of presentation of this document, the countries most focused on the development of solar energy research are China, India and the United States. Also, the results show that the Indian Institute of Technology Systems and the Chinese Academy of Sciences, are the most interested in the research and development of solar energy, followed by other Asian and U.S. universities such as the Chinese Academy of Sciences and the U.S. Department of Energy - DOE, respectively.

Globally, 3965 institutions are involved in solar energy development research, which is a topic of great research interest for their studies. ‘China’s new power stations matter.”

REFERENCES

Apostoleris, H., Stefancich, M., Chiesa, M. (2016), Tracking-integrated systems for concentrating photovoltaics. Nature Energy, 1(4), 1-8.

Borhanazad, H., Mekhilef, S., Saidur, R., Boroumandjazi, G. (2013), Potential application of renewable energy for rural electrification in Malaysia. Renewable Energy, 59, 210-219.

Calderón, A., Barreneche, C., Hernández-Valle, K., Galindo, E., Segarra, M., Fernández, A.I. (2020), Where is Thermal Energy Storage (TES) research going?-A bibliometric analysis. Solar Energy, 200, 37-50.

Chekalin, A.V., Andreeva, A.V., Davidyuk, N.Y., Potapovich, N.S., Sadchikov, N.A., Andreev, V.M., Malevskii, D.A. (2022), High-efficiency photovoltaic modules with solar concentrators. Technical Physics, 66, 1-7.

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., Lim, W.M. (2021), How to conduct a bibliometric analysis: An overview and guidelines. Journal of Business Research, 133, 285-296.

Đurašković, J., Konatar, M., Radović, M. (2021), Renewable energy in the Western Balkans: Policies, developments and perspectives. Energy Reports, 7, 481-490.

Edward, A., Dewi, T. (2019), The effectiveness of solar tracker use on solar panels to the output of the generated electricity power. IOP Conference Series: Earth and Environmental Science, 347(1), 012130.

Kleissl, J. (2013), Solar Energy Forecasting and Resource Assessment. Cambridge, Massachusetts: Academic Press.

Mangiante, M.J., Whung, P.Y., Zhou, L., Porter, R., Cepada, A., Campirano, E. Jr., Torres, M. (2020), Economic and technical assessment of rooftop solar photovoltaic potential in Brownsville, Texas, USA. Computers, Environment and Urban Systems, 80, 101450.

Moral-Muñoz, J.A., Herrera-Viedma, E., Santisteban-Espejo, A., Cobo, M.J. (2020), Software tools for conducting bibliometric analysis in science: An up-to-date review. Information Professional, 29(1), 3.

Oh, M., Park, H.D. (2019), Optimization of solar panel orientation considering temporal volatility and scenario-based photovoltaic potential: A case study in Seoul National University. Energies, 12(17), 3262.

Philipps, S.P., Bett, A.W., Horowitz, K., Kurtz, S. (2015), Current status of concentrator photovoltaic (CPV) technology (No. NREL/TP-5J00-65130). Golden, CO, United States: National Renewable Energy Lab.

Rizk, J.C., Chaiko, Y. (2008), Solar tracking system: More efficient use of solar panels. World Academy of Science, Engineering and Technology, 41(2008), 313-315.

Shehatta, I., Al-Rubaish, A.M. (2019), Impact of country self-citations on bibliometric indicators and ranking of most productive countries. Scientometrics, 120(2), 775-791.

Silva-Rodriguez, D. (2008), Photovoltaic Concentrator for Fiber Optic Illumination of Multi-junction Cells, PhD Thesis. Madrid: Universidad Politécnica de Madrid.

Tiwari, G.N., Tiwari, A. (2016), Handbook of Solar Energy. Vol. 498. Singapore: Springer.

Wilkins, M. (2017), Multi-junction Solar Cells and Photovoltaic Power Converters: High-efficiency Designs and Effects of Luminescent Coupling Doctoral Dissertation. Ottawa: Université d'Ottawa/ University of Ottawa.