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Solar Photovoltaic panels utilization to extract clean and green energy for utility application using PVsyst software: A Bibliometric Review

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Solar Photovoltaic panels utilization to extract clean and green energy for utility application using PVsyst software: A Bibliometric Review

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This paper presents a survey on educational documents in the field of solar photovoltaic (PV) utilization to extract clean and green energy. The main purpose of this bibliometric analysis is to understand the size of the available documents for the research of PV solar panel utilization using PVsyst. This detailed review was conducted in the PV research, literature considering all subjects from the Scopus database. The pattern for the specific arrangement of keywords was separated with the recovered results from the Scopus database, publication type, year of publication, distribution conveyance by nations, subject classes, association, authors, and financing organizations. It was discovered from the close examination that mainly conferences, articles, and review papers from the United States of America, India, and Spain have significant contributions in publication. The time series dataset started in 1999 till date. Major contributions are from the branches of Engineering and Energy, Material Science, Physics, and Astronomy.

Keywords: Bibliometric Analysis; Clean Energy; Photovoltaic Systems; Performance Measurement; PVsyst

1. Introduction

Clean energy is getting progressively predominant in created nations and throughout the planet (Sharif, Meo, Chowdhury, & Sohag, 2021; Zou, Zhao, Zhang, & Xiong, 2016). Sustainability is a minimal effort and harmless to the ecosystem approach to get the energy we need to control our society (Iram et al., 2021). Photovoltaic (PV) solar energy can be the primary energy source in modern times (Abu-Rayash & Dincer, 2021). Bibliometric surveys assume a fundamental part in scholarly exploration to accumulate existing information and analyze a field's condition (Rowlands, 1999; J. Sayyad & P. Nasikkar, 2020). Scientists ordinarily gather accessible proof on a point or issue preceding directing new examination to survey the condition of the generally accessible proof. It is standard for the board researchers and scientists in related fields such as accounting and finance. Conditions may arise in research assessment where the examination of all open dissemination data will not or cannot be the circumstance, wherein some light should be shed on reviewing sufficiency. We have attempted to explore this since it is a test introduced by bibliometric assessment. It maximizes that more extraordinary models decrease the distinction of the mean anyway at what test size does detachment between a movement of datasets become satisfactorily clear to satisfy evaluation requirements (Rezaei & Gholamian).

Research assessment on clean and green energy systems has a significant benefit in terms of the world's ecology, environment, and politics. Almost 3/5th of Renewable energy sources will be used for electricity globally, and 2/5th will be used as fuel by mid-century (Mukerjee & Dasgupta, 2008). Furthermore, transitioning to sustainable energy prudence would have substantial environmental and other benefits that cannot be measured in economic terms (Myungsik, 2011). Carbon dioxide (CO²) emissions are expected to be reduced by 75 percent until 2050 compared to 1985 levels, owing to

more efficient energy use and widespread use of renewable energy sources (Abdullah & Pauzi, 2015).

Solar Renewable energy is more environment friendly than typical power resources over a generation of energy. There are innumerable benefits of using solar energy, which is broadly divided into socio-financial and ecology problems (Stevović, 2017). Usage of solar electricity technology has numerous influences like depletion of emission of CO² (Adanu, 1994), which reduces the greenhouse effect and poisonous emission of CO². It will prevent soil pollution, significant lowering of transmission value additionally water resources will have significant improvement (Sevastos & Koliadima, 2014). The usage of solar technology will help the economy by increasing employment opportunities; moreover, it will be helpful in providing electricity to the rural and isolated areas/groups. It will slowly but surely incorporate energy independence on Non-renewable sources of energy (Enslin, 1991). Furthermore, it will provide variegation and stabilization of energy supply.

Solar cells are the fundamental component in the solar PV systems, are noticed to have many applications as they are simple, small, and have higher electricity to weight ratio (Fedorov, 2015). Their behavior is more like a current supplying device than a voltage supplying device, i.e., current output increases with increasing of solar insolation, the voltage output remains steady though there is a change in solar insolation (Malvoni et al., 2016). This being the reason behind sizing PV panels for a particular purpose. PV cell's output purely depends on solar insolation (Sharma & Goyal, 2021). Its module's (PV module) characteristics depend on the fact that cell working temperature and alteration in solar irradiance will non-linearly influence the current-voltage and power voltage (Sayyad & Nasikkar, 2021; J. K. Sayyad & P. S. Nasikkar, 2020). Other than cell working temperature and solar irradiance PV module is also controlled by its

operating point on the I-V plane (Barua, Prasath, & Boruah, 2017; Fadhel et al., 2019; Sayyad, Nasikkar, Singh, & Ozana, 2021). Higher efficiency results are received when the PV module is forced to function near Maximum Power Point (MPP) (Malvoni et al., 2016).

2. Study Design

Implementation of the Bibliometric approach was done from 1999 to 2021. The duration of the study was determined keeping in mind that the “National Renewable Energy Laboratory” achieved an adequate record of thin-film PV solar cells in 1999. Efficiency achieved was 18.8% for a prototype solar cell, and it was 1% more than that of 1998 and increasing installation of PV capacity reached 1000 Megawatts in 1999 worldwide.

2.1 Keyword Framing

During Bibliometric Analysis, utmost significance is given to keyword selection as keywords directly impact the findings and possible outcomes. This part consists of the Scopus records set into the concept to guide significant keywords determined for continuous solar PV panel utilization using PVsyst research. The Scopus information set inquiry was collected into three squares as crucial, auxiliary, and discretionary keywords. The proposed keywords processes carried out for this investigation, as stated in Table 1. in the wake of assessing various mixes of the keywords, closed on the going with the path of motion of keywords.

Table 1: Planned search tactic for set of keywords

Primary-Keyword (AND)	("Photovoltaic" OR "PV" OR "PV Systems") AND (" PVsyst " OR "PVComplete" OR "PV*SOL")
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Secondary-Keywords (AND)	(" Solar panel" OR "Solar cell" OR "Solar Module") AND ("Clean energy" OR "Green energy" OR "Solar energy")
Optional-Keyword (AND)	("Performance measurement" OR "Performance monitoring" OR "Irradiance") AND ("IV Curve" OR "Current-Voltage" OR " Power" OR "Efficiency")

The search was further refined and restricted to the inclusion of English publications. There is a total of 272 English publications, as shown in Table 2. Considering the distribution of documents by source type, the majority are from journal paper, as shown in Table 3.

Table 2: Language-wise distribution of research publications

Language	Number of publications
English	272
Chinese	1

Table 3: Publication source type-wise distribution of research documents

Source Type	Number of Publications	Percentage
Journal	198	72.52
Conference Proceeding	60	21.97
Book Series	8	2.93
Book	7	2.56

2.2 Analysis using Scopus Database

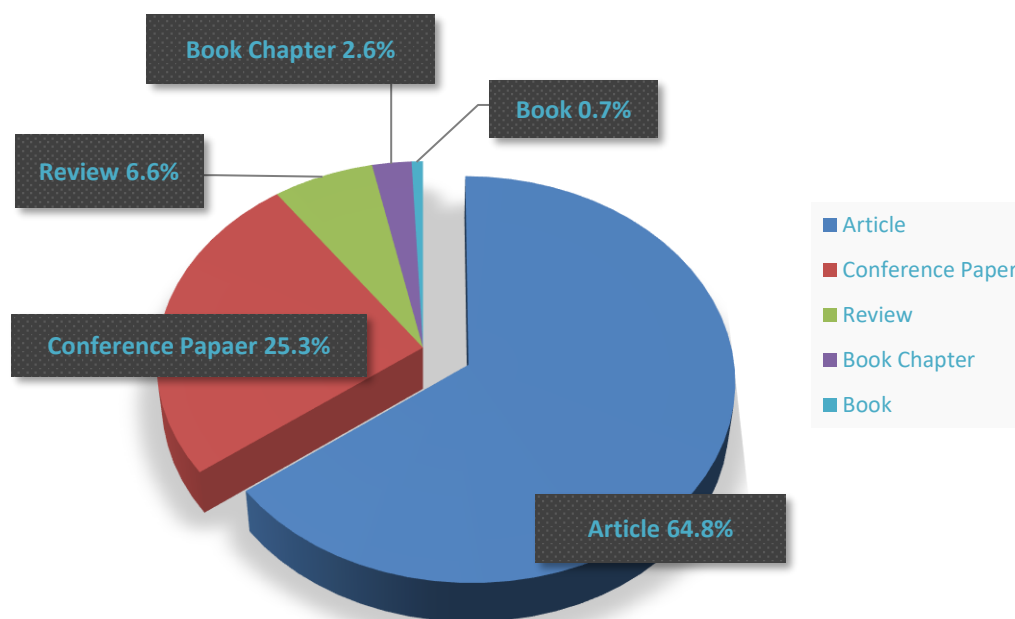
This section presents a flexible bibliometric assessment of records given by the Scopus database. Elsevier created Scopus in November 2004 which is a bibliographic database and is very much useful to find research trends and research gaps (Matutinovic, 2006). It was established with 22800 titles from more than 5000 global publishers, with an aim in mind to supply most detailed view on the exploration yield worldwide in the fields of

science, medication, humanities, technology, and sociology. As stated in the Introduction, solar PV panels utilization is a focused research area. This paper dedicated to Solar PV panels utilization research. Fundamental investigating through the established search method for keywords generated in each of the 273 papers.

Document type-wise trend

The analysis from shows that the researchers have published near about 64.8% articles,

Document Type Trend



25.3% conference papers of the total publications on solar PV panels utilization to extract clean and green energy for utility application using PVsyst software as shown in Figure 1. It also shows that only 6.6% review, 2.6% book chapter and 0.7% book have been published on the same.

Figure 1: The Documentation type-wise trend of publications on solar PV panels utilization to extract clean and green energy for utility application using PVsyst software accessed on 26th April 2021(Source: <http://www.scopus.com>)

Year-wise trend

The analysis from Figure 2 shows that the researchers are publishing journal papers, conference papers, articles, book chapters, etc., since 1999. Till 2011 the trend shows a consistent increase in the number of publications. Most of the papers were published during 2017-2020, as shown in Table 4. As per the analysis maximum number of papers, articles, books, etc. were published in 2020.

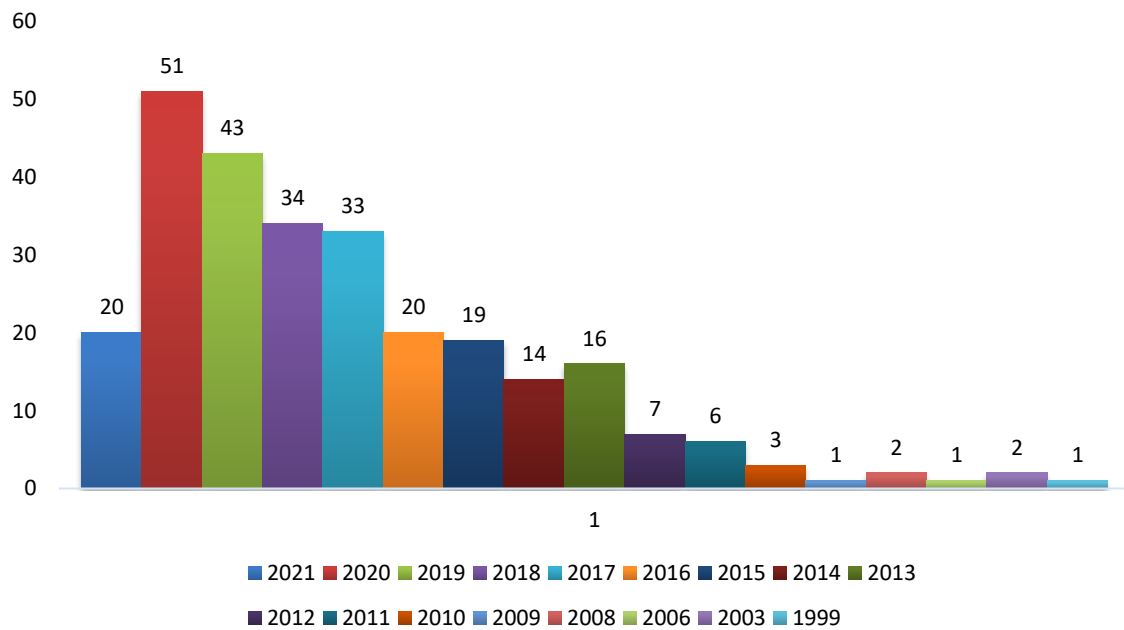


Figure 2: Year wise trend of publications on solar PV utilization to extract clean and green energy for utility application using PVsyst software accessed on 26th April 2021(Source: <http://www.scopus.com>)

Table 4: Year-wise trend of publications on solar PV utilization to extract clean and green energy for utility application using PVsyst software accessed on 26th April 2021(Source: <http://www.scopus.com>)

Year	No. of Publications	Year	No. of Publications
1999	1	2011	7
2000	0	2012	8
2001	0	2013	18
2002	0	2014	15
2003	2	2015	19
2004	0	2016	20
2005	0	2017	33
2006	1	2018	36
2007	0	2019	43
2008	3	2020	51
2009	1	2021	20
2010	5		

Source-wise trend

The analysis from Figure 3 shows that the Progress in Photovoltaics research came into the picture during the year 2003, and a maximum number of documents were published in 2020, which were 14 in total, 7 in solar energy, 5 in renewal energy, and 2 IEEE Journal published on PV. In 2018, a total of 4 renewable and sustainable energy reviews were published, and two papers were published on progress in photovoltaics research and application. Significant change can be seen in 2017, as ten documents were published this year, and from the year 2017 onwards, solar energy & renewable energy publications lead in the PV field.

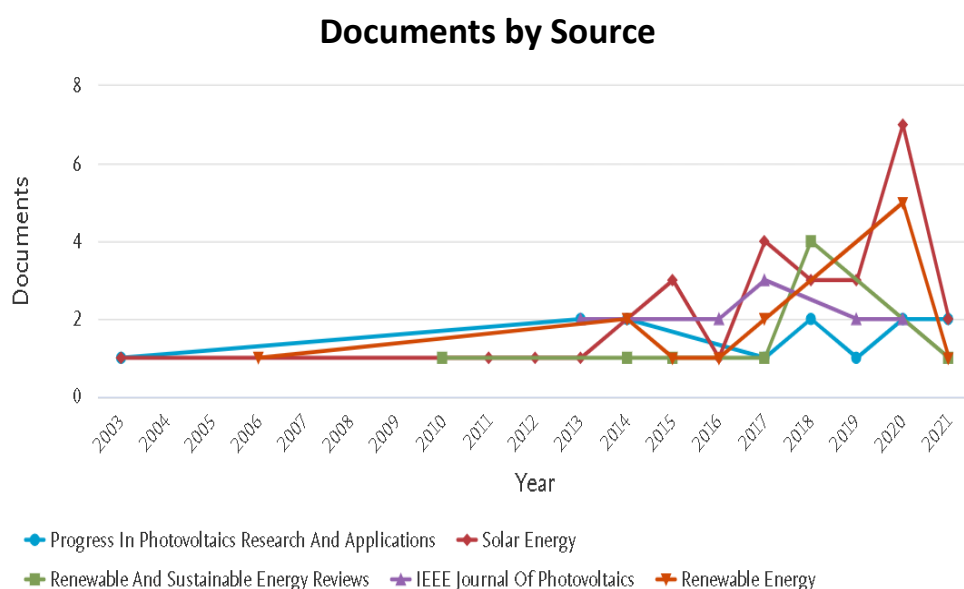


Figure 3: Documents distribution per year by source in solar PV panels utilization to extract clean and green energy for utility application using PVsyst software accessed on 26th April 2021(Source: <http://www.scopus.com>)

Author -wise trend

In this study, the number of publications for the top 10 researchers is given as a line chart, as shown in Figure 4. Deline, C. from the “Network of Photovoltaic Technology, Purdue University, West Lafayette, U.S.” is leading the pack with five books in the review period. Deline, C. also published documents with “National Renewable Energy

Laboratory, Golden, U.S” in the same field.

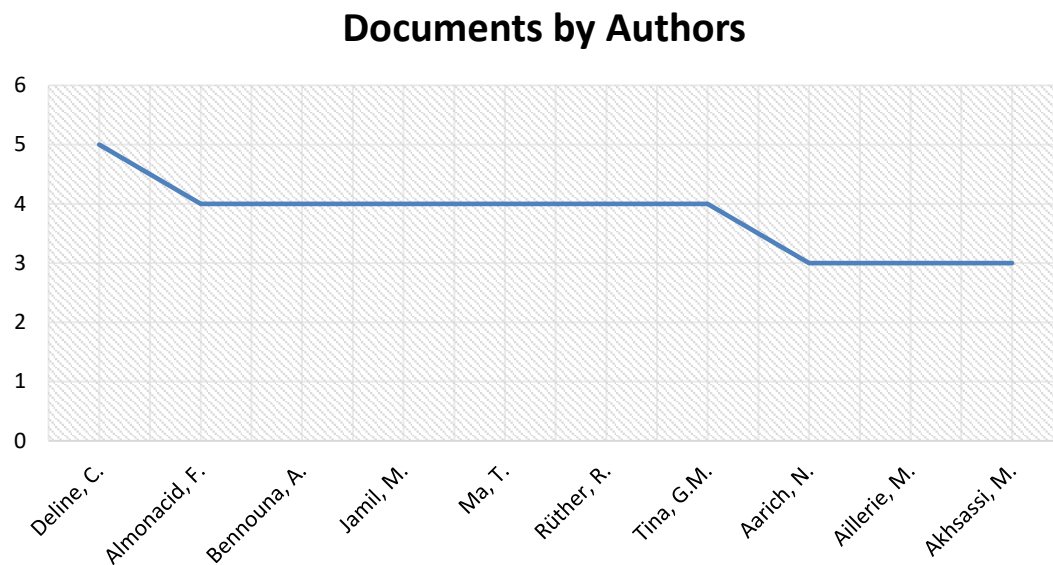


Figure 4: Top ten authors who have published their research documents in the field solar PV panels utilization to extract clean and green energy for utility application using PVsyst software accessed on 26th April 2021 (Source: <http://www.scopus.com>)

Affiliation statistics

The research Analysis of the top 10 universities/ countries/ organizational mergers portrayed that the United States of America has the maximum number of documents, as shown in Figure 5. "The National Renewable Energy Laboratory from the U.S." has published 12 documents, and First Solar, Inc. from the U.S. published 5 documents. Surprisingly, a nation like Algeria is very much focused on research into renewable energy. "Centre de Développement des Energies Renouvelables Algeria" is on the top 2 positions in the list with eight published documents followed by the Spain's University of Jaen with seven documents, and for India, Jamia Millia Islamia Central University published seven documents.

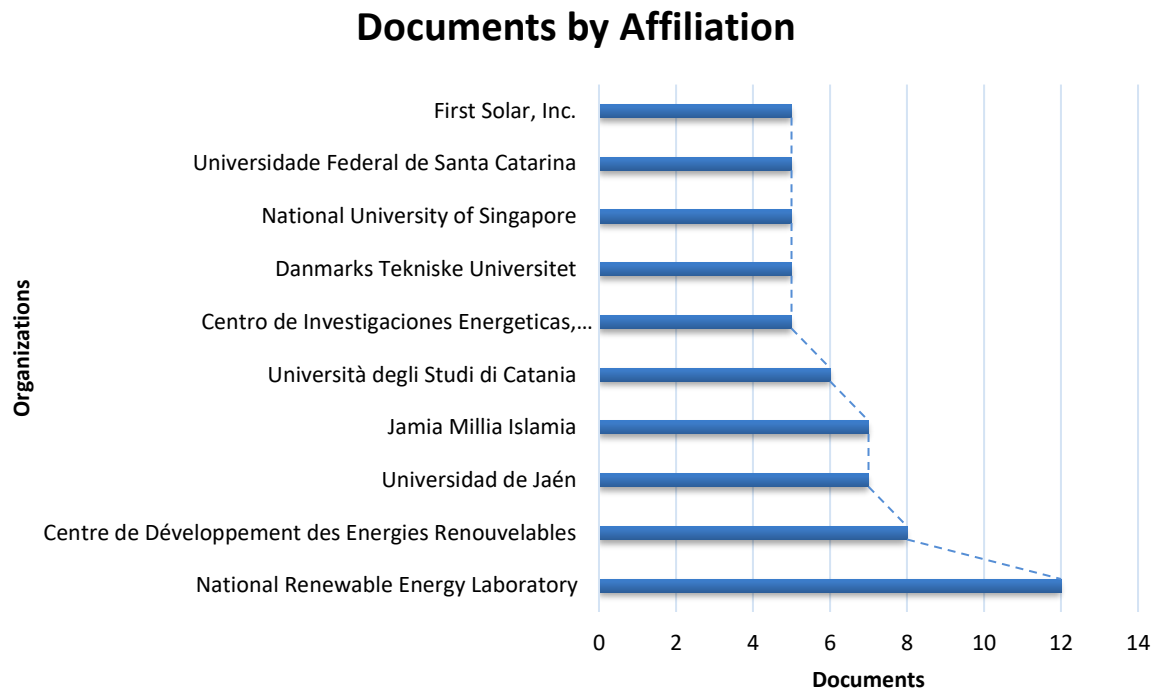


Figure 5: Top ten Affiliation-wise institutes which have researched solar PV panels utilization to extract clean and green energy for utility application using PVsyst software accessed on 26th April 2021(Source: <http://www.scopus.com>)

Country-wise trend

In this analysis, the authors from 63 distinct nations are interested in publishing the documents, as shown in Figure 6. The top 10 active nations took part in publishing 214 (78.3%) documents. The United States of America was at the top position acquiring over 43; 15.7% regarding the number of published documents. Six nations from the top 10 list were from Europe, three from Asia, and one from North Africa. The geographic dispersion of the analyzed report showed that world regions with a high predominance of solar energy, such as the Middle East and North Africa, had the most negligible research contribution, only Algeria in the list from North Africa, and it is exciting to see that most of the research literature comes from the USA and India.

Documents by Country

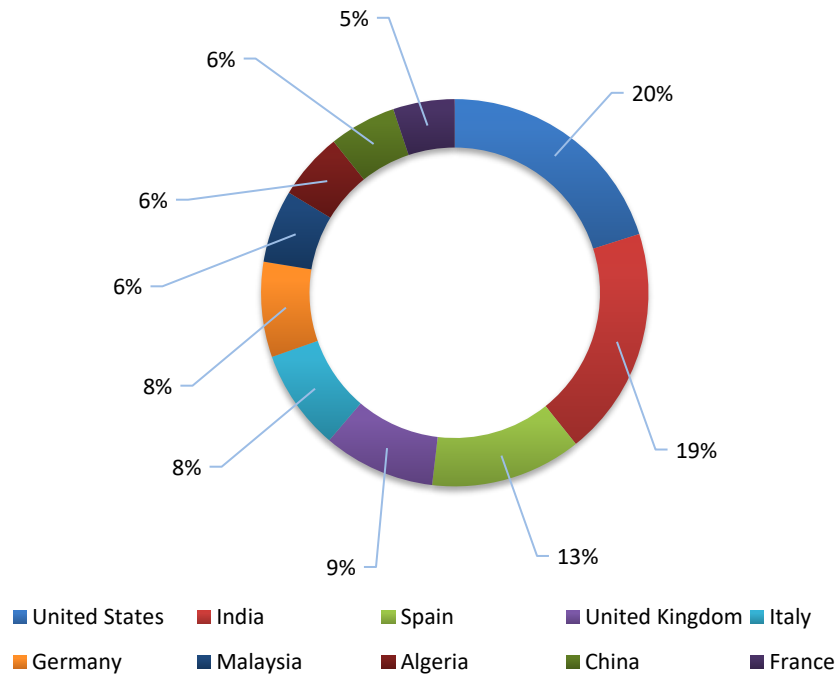


Figure 6: Top ten countries or territory which have researched solar PV panels utilization to extract clean and green energy for utility application using PVsyst software accessed on 26th April 2021(Source: <http://www.scopus.com>)

Subject area-wise

In this section, the analysis of the recovered data showed that 170 (29.6%) documents were from the Energy field, 139 (24.2%) were from the Engineering field, 81 (14.1%) were from Material Science, and 49 (8.5%) were from Physics and Astronomy. These values give an idea of a topic or study area that has had a significant impact on research. As shown in Figure 7, Engineering, Energy, and materials science donated more than 65% (67.9%) of research literature and gradually evolved in-depth study of the solar PV panel utilization. It is also noteworthy that very little research has been done in the fields of Economics, Econometrics and finance, Earth & Planetary Sciences.

Documents by subject area

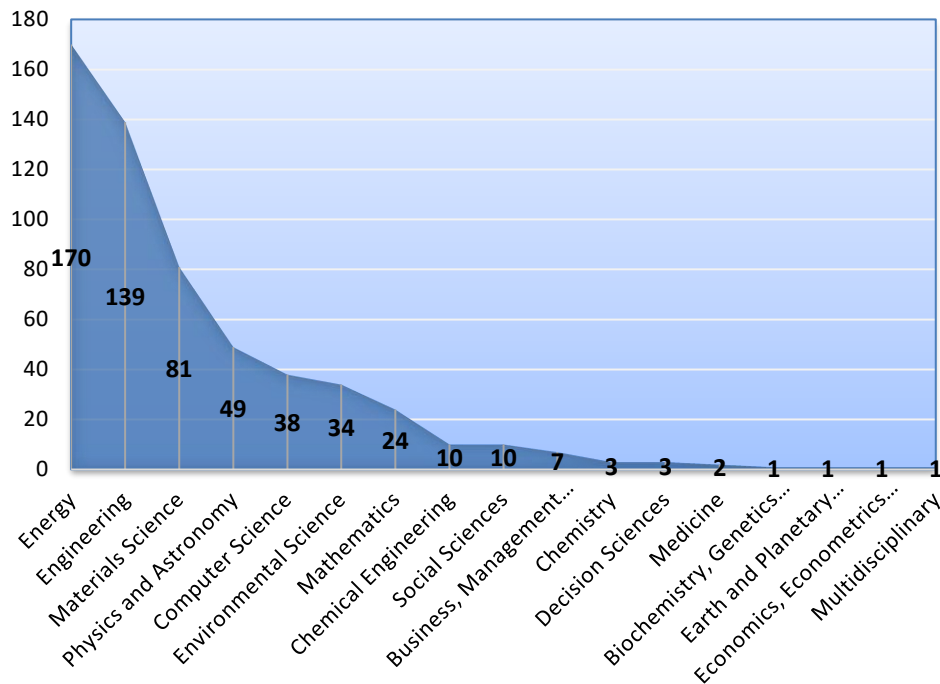


Figure 7: Subject area-wise number of documents distribution published on solar PV panels utilization to extract clean and green energy for utility application using PVsyst software accessed on 26th April 2021(Source: <http://www.scopus.com>)

Funding sponsor-wise

Figure 8 shows the top ten sponsors of research funding in the PV. As a result, it is not surprising that most of the research funding from the USA is accepted by 15 documents. Research and Development (R&D) funding from the European Commission (EC) of Belgium received second place with nine documents. Nowadays, many countries provide economic support by allocating R&D budgets to become self-sufficient in the growing capacity needed in the future. Countries like Algeria and India surprisingly played a significant role in the last five years.

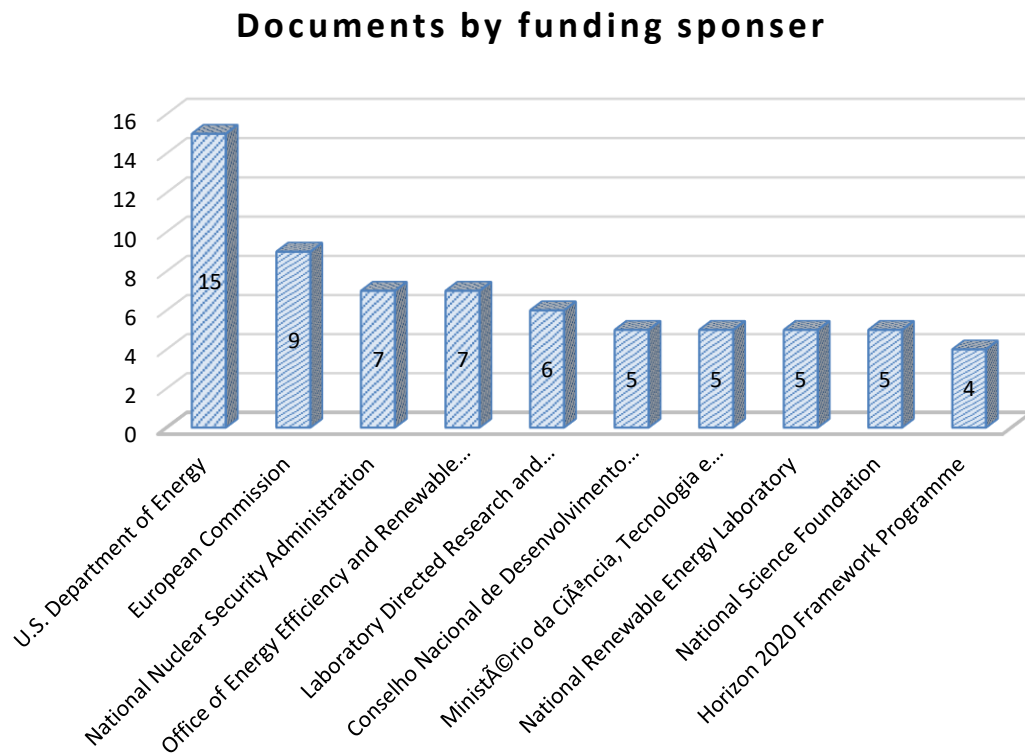


Figure 8: Leading sponsor who has provided funding for the publications in solar PV panels utilization to extract clean and green energy for utility application using PVsyst software accessed on 26th April 2021 (Source: <http://www.scopus.com>)

3. Limitations of this study

The current study has some limitations as the data extraction from the Scopus database is purely dependent upon a specific set of keywords relevant to that field. A slight manipulation in a keyword or an operator will drastically change the number of documents published in that research domain. Many important documents may not have been received through this analysis and could not become part of this study. The usage of the Scopus database to retrieve literature on PV solar panel utilization a particular bias toward nations with a considerable number of journals listed in Scopus. Scopus looks biased towards educational journals in which files are published in English (Albarillo, 2014).

Consequently, documents in PV solar panel utilization published in non-English have

not been very well recognized. Like every other bibliometric research, the present-day observed no longer consisted of grey literature (Di Cesare & Ruggieri, 2006). The search method which is used in the study may lead few false-negative or false-positive effects. consequently, interpretation of the outcomes needs to think about those restrictions.

4. Future scope and opportunities

As research and statistical data analysis are the key sources of scientific development, the publications and upcoming research documentations in the relevant field would help the researchers find various distractions and research gaps in harnessing green and clean energy. The detailed analysis of regions and countries shows us pioneering nations in which some nations are overgrowing in terms of research and publications; Exploration in PV panels precise position and orientation needs to be done as an outstanding increment in efficiency is observed if panels are precisely oriented towards the irradiance of sun rays. Changes in several kilometers of distance geographically led to the changes in altitude, sun ray's irradiance, air density, pollution, and other factors that need to be observed more carefully regarding ideal positions of PV panels.

Equatorial regions such as Sub-saharan countries and middle east countries are facing high energy demands and low infrastructure development while many of the regions have no access to electricity at all. As these regions face the highest irradiance of sun rays than any geographical region on earth and availability of vast lands with no practical usage are also there which can be efficiently used for solar-powered plants. By analysis and observations, the demand for high usage can be overcome. If these lands were appropriately used for PV panel-based power plants, it would be possible to provide enough electricity to the whole African continent. It is also the ideal solution to overcome essential human resource (electricity) in the situation of overpopulation and

overconsumption.

5. Conclusion

The appraised data for this study is extracted from the Scopus database, which is an analysis of documents based on specific keywords, focuses on energy generated from the PV panels using PVsyst software. A total of 273 papers have been received from 1999; a consistent growth till 2014 is observed about 5-7 papers each year and a spike in 2017 with 33 documents including 3 IEEE journals is observed, and in the year 2020, most of the documents about 51 are released. National Renewable Energy Laboratory (NREL) of USA, as the pioneer affiliated with most of the documents plus the U.S. Department of energy, comes at the top as the funding sponsor, followed by Japan, India, Algeria, and Spain. Countries like Algeria and India are one of the most active and consistent with an exponential increment in the last five years has been observed in research, especially in this field. 54% of the total documents are affiliated in Engineering and Energy field, and the rest 46% are in many specific fields, including Psychology, Economics, Econometrics and Finance, and Agriculture. These are the key countries that contribute the most to green energy generated by PV panels, including PVsyst software. All the studies and research are the central pillar of contribution towards the development of more efficient and powerful PV systems and create awareness about the importance of new generation clean and green energy.

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