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A BIBLIOMETRIC ANALYSIS OF GLOBAL RESEARCH TRENDS ON ROOFTOP SOLAR ADOPTION USING SCOPUS DATABASE

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ABSTRACT: In recent years, renewable technologies, especially solar photovoltaic (PV) have become one of the most promising tools for countries worldwide to achieve energy security in the long run. This study reviews the adoption of Rooftop Solar Photovoltaic (RSPV) by the residents for its many advantages of generating employment, lowering transmission losses and decreasing dependence on fossil fuels apart from allowing a consumer to earn by feeding the extra power to the grid. However, in the absence of a thorough understanding of the knowledge domain surrounding solar PV adoption, this study attempts to investigate the global trend in the adoption of RSPV systems research. The researchers used a systematic and comprehensive review of academic literature related to residents' adoption of rooftop solar PV by bibliometric analysis method using the Scopus database. Scientific Mapping of the database revealed important themes, and past and future trends by making citations and co-occurrence of keyword analysis. In doing so, this research fosters our understanding of interesting topics and expands collaborative networks on the current phenomena. The study also discusses the theory and practical implications and calls for a future research program on the adoption of solar PV studies.

KEYWORDS

Bibliometric Analysis, Rooftop Solar Photovoltaic, Renewable technologies, Scopus Database, Adoption, Scientific Mapping.

Introduction

Today, the main issues impeding clean energy development are environmental degradation and climate change. Deploying non-conventional energy sources is crucial in achieving the sustainable development Goal-7 of ILO. A considerably clean and sustainable renewable energy sources is the Solar PV energy systems which imparts a lot of advantages to social, economic and environment development (Fauzi et al., 2023). Solar energy, which is produced by converting solar light into electrical and thermal energy, is an ample form of natural resource (Ludin et al., 2018). The use of solar photovoltaic energy could decrease greenhouse gas emissions, minimize reliance on fossil fuels, and generate opportunities for renewable energy (Barnes et.al., 2022). Solar PV technology has been embraced by many industries, particularly those that operate in the public sphere, like lighting buildings, roadways, using concentrated solar power (CSP) technologies, and floating photovoltaics (FPA) (Dixit, 2020). A growing population and intensive economic development is creating demand for energy (Irfan et al., 2021). The consumption of fossil fuels which are still the major sources of energy (Yang, 2021) is unsustainable. Further, it is detrimental to the environment because of its huge greenhouse gas (GHG) emission during combustion (Olabi & Abdelkareem, 2022) and thus leading to severe health problems. Coal and natural gas, the two-fossil fuels emit a large amount of deadly CO2 and GHG thus contributing to a major increase in the temperature of the earth. These detrimental environmental threats have led to numerous efforts worldwide to substitute fossil fuels with renewable energy (Leonard, 2020) and adopt non-fossil sources as a sustainable energy source (Abbasi et al., 2022). Renewable energy sources including wind, solar, biomass, and geothermal energy, help to create clean electricity and are estimated to have reduced global carbon emissions by 70% (Choudhary & Srivastava, 2019). Among these energy sources, solar energy is thought to be the most plentiful sustainable source of clean energy for

meeting earth's future demand (Kahng et al., 2020). And it is cost-free too. Renewable energy lowers our dependence on GHG emissions thus preventing climate change (Wang et al., 2022).

Extant literature shows that consumers view Rooftop Solar Photovoltaics (RSPV) as having potential advantages for the environment (Tawalbeh et al., 2021), a decrease in local pollution (Rathore et al., 2021), a useful net energy life cycle (Raugei et al., 2012) and as a social status symbol (Ojong, 2021; Akter & Bagchi, 2021). Gradually, residential users are also encouraged to use rooftop solar PV for a number of reasons (Abreu et al., 2019) The Governments everywhere are strongly urging homeowners to install roof top solar power. By offering tax exemptions, grants, rebates, and Feed-in Tariff (FiT) programs (Alipour et al., 2021), However, the success or failure of these initiatives mainly depends on the household consumers' adoption of rooftop solar PV. Individuals' motivation to install rooftop solar PV and related technologies is clearly lacking, as noted by Sommerfeld et al. (2017). In their systematic literature review of 199 publications on residential solar PV technology studies, Alipour et al. (2021) found 13 behavioral theories which can be linked to 36 intervention variables. A meta-analysis of eight sufficiently homogeneous studies by Schulte et al. (2022) discovered a correlation between residents' adoption of solar PV, their subjective norm, intention and environmental concern.

There is a dearth of research on rooftop solar PV adoption. Hence, a bibliometric review analysis derived from published literature from the Scopus database shall create a scientific framework and body of knowledge. The objective of this study is to examine the past, current and future research trends of rooftop solar PV adoption and give a thorough understanding on the subject.

To achieve these objectives, the present bibliometric analysis examines the temporary dissemination trends of journal articles on rooftop solar adoption by: (1) presenting contributions of leading authors and their affiliations, leading countries, subject areas, leading funding agencies etc.; (2) displaying top journals and publishers; (3) determining countries' dominance based on major publications; and (4) providing insight to the research potential in this domain by scientifically mapping citations, co-occurrence of keywords analysis. The study is of importance and will be useful for academicians and policymakers alike. Reviewing the knowledge gaps of roof solar PV adoption, deriving novel research areas could facilitate discussion on current and future research possibilities.

Methodology

Bibliometric Approach

Bibliometric is a statistical analysis that offers bibliographic data in the form of publications and citations (Broadus, 1987) that gives an acumen into academic literature (Benckendorff and Zehrer, 2013; De Bellis, 2009). Publications applying the bibliometric method evaluate past research activities, trace evolution and progress of a research domain, evaluate the current knowledge structure and predict future trends (Kastrin & Hristovski, 2021). By analyzing the database, the bibliometric analysis provides insight into the growth of academic literature, knowledge transfer within a given field over a long period (Van Raan, 2005; Abbas et al., 2020). Apart from using the scopus analysis tool to determine the leading authors and their affiliations, leading countries, subject areas, top journals, leading funding agencies etc., the current study also uses the science mapping technique to explore the growth of global trends in adoption of RSPV research. VOSviewer 1.6.20, a bibliometric mapping and visualisation software tool was used to discover the major themes of RSPV adoption research through citation analysis, co-word analysis of published documents from the Scopus database.

2.2 Research design and data collection process

The Scopus database mining was carried out on February 10, 2024. The criteria used for search within was set to Article title, Abstract and Keywords and search documents included 'roof AND top AND solar AND adoption'. The date range was left open so as to get documents as old and as recent as possible. The current research employed the following search string to identify related publications:

TITLE-ABS-KEY(roof AND top AND solar AND adoption) AND (LIMIT-TO (LANGUAGE, "English")). This query string's output was 34 documents.

Results and Discussion

Scientific mapping using the Scopus analysis tool

a. Research Interest and Growth in Publication Output

A total of only 34 research articles were published for a total range duration starting from 2004 to 2024. (Fig. 1). The oldest publication dates back to 2004 and there was no record of publication from the year 2005 to 2010. There were 04 publications during 2011 and 2012 and again the year 2013 recorded nil publication. Begining 2014, we can see a steady interest in rooftop solar adoption research. The year 2022 saw the maximum annual publication (06) indicating a gradual growth of research interest in this area and is expected to increase further in the coming years.

The increment in the publication may be attributed to realisation by all the stakeholders that solar energy is the most affordable and sustainable option for all including residents. Further, goals of carbon emissions reduction to net zero cannot be achieved without focussing our research on alternative forms of energy, especially adoption of roof top solar PV systems.

b. Types of documents published

The documents that are recorded in the Scopus database include articles, conference papers, book chapters etc. It can be observed that out of the 34 published documents, there are 21 research articles on rooftop solar adoption. Figure 2 shows the details of the same.

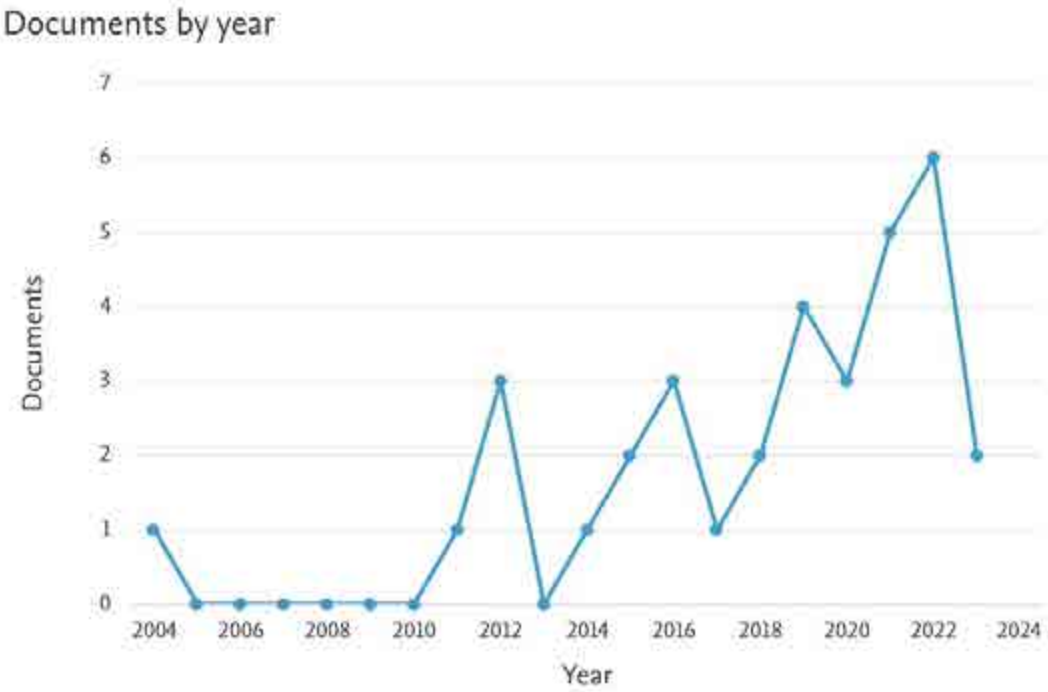

Figure 1: Number of research articles published per year

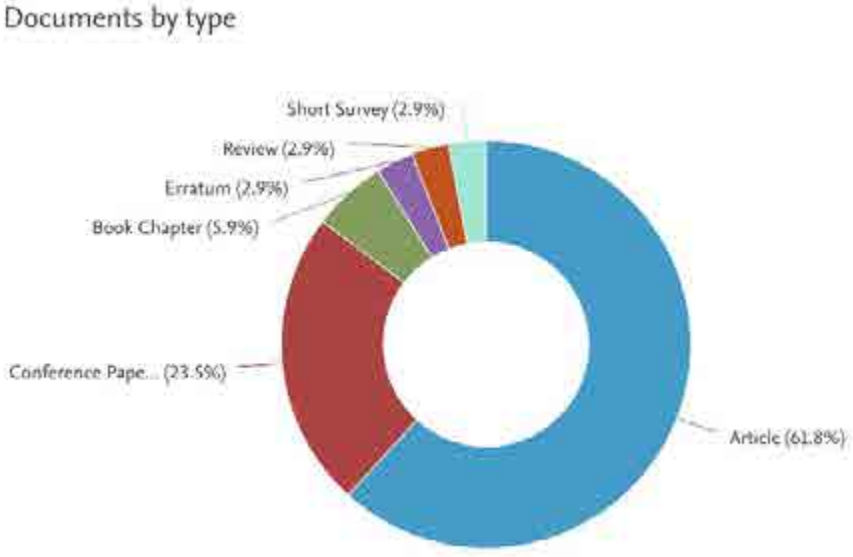

Figure 2: Types of published documents

c. Subject area of rooftop solar adoption publications

Records found in the Scopus database throws light on the subjects that are investigating rooftop solar adoption. It can be seen that the researchers belonging to the energy and engineering subjects have published almost 46.3 percent of the documents. Environmental Science, Computer Science, Social Sciences and Business, Management and Accounting have more than 05 publications while all others have 02 publications each (see Figure 3).

d. Preferred Journals

The 34 documents in the Scopus database has been published in different journals. Our findings showed that the journal Energy and Buildings, an Elsevier Publication has 01 publications each in the year 2012 and 2015 on adoption of roof top solar PV research. The journal has a cite score of 11.8, SJR of 1.068 and a SNIP of 1.922. Similarly the International Journal of Management, an IAEME Publication having a cite score of 0.1 and a SNIP of 0.322 has 02 publications in 2019. The third journal named Water and Energy International from the publisher Central Board of Irrigation and Power has 01 publications each in the year 2016 and 2019. (Figure 4). This journal has a cite score of 0.3, SJR of 0.124 and a SNIP of 0.182. Other sources of publication such as, Asian Applied Energy, Asia Pacific Journal of Public Administration etc. have 01 publications each.

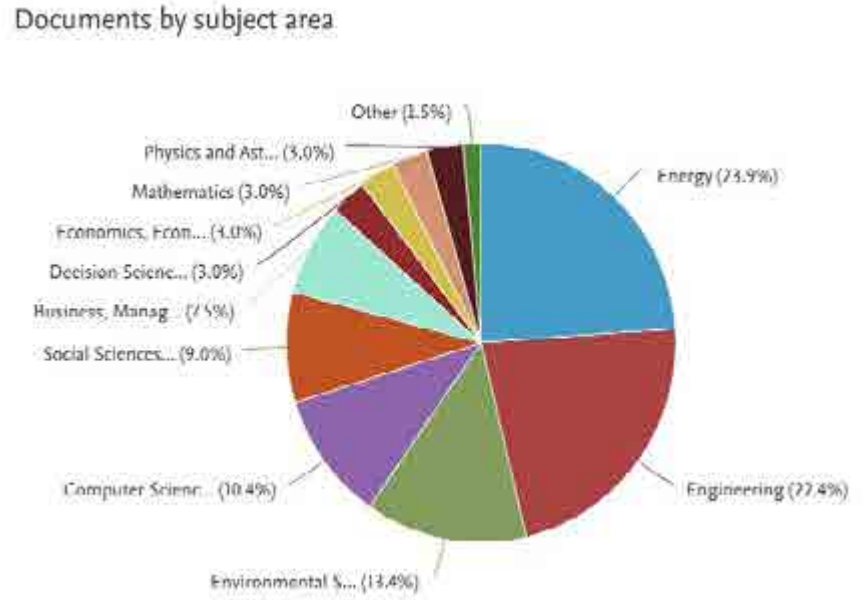

Figure 3: Publications by subject area

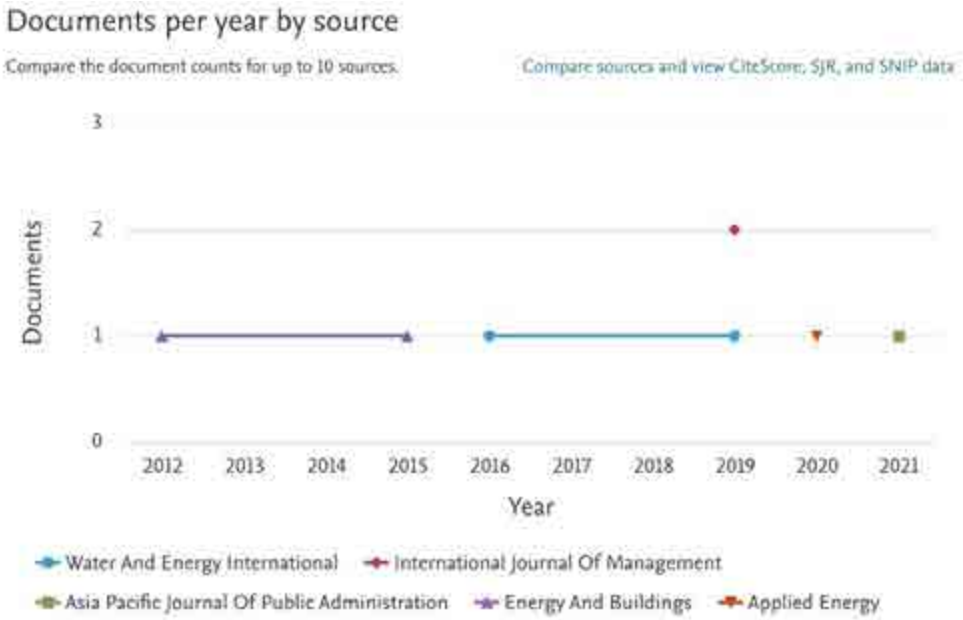

Figure 4: Documents per year by Source

CiteScore is an indicator of the impact that a journal has on its readers and its assessment metrics are based on the number of citations in the Scopus database. Nonetheless, it can't be argued that CiteScore should be taken as the only criteria for assessing journals sand publications. Along with the CiteScore, authors may also consider whether the journal is contributing to the progress of that research area and if it is reaching the right audience or not.

e. Leading Authors and their affiliations

The Scopus database showed records of a total 73 authors who have written on rooftop solar adoption. Figure 3 lists the 10 most prominent authors in adoption of roof top solar PV research. As we can see, the authors named Ahmed, S. and Quraishi, K.S. have 03 publications each while all the others have 01 publications each (see Figure 6).

The leading authors who are working in rooftop solar adoption research are affiliated to numerous institutions of different countries (Figure 6). Authors affiliated to Aligarh Muslim University in India top the ranking with 03 publications. Similarly, authors having 02 publications each have affiliations from Tata Power Delhi Distribution Limited, University of Michigan-Dearborn in USA, ETH-Zurich in Switzerland, University of Hertfordshire in UK, Amity University and College of Engineering and Computer Science in India.

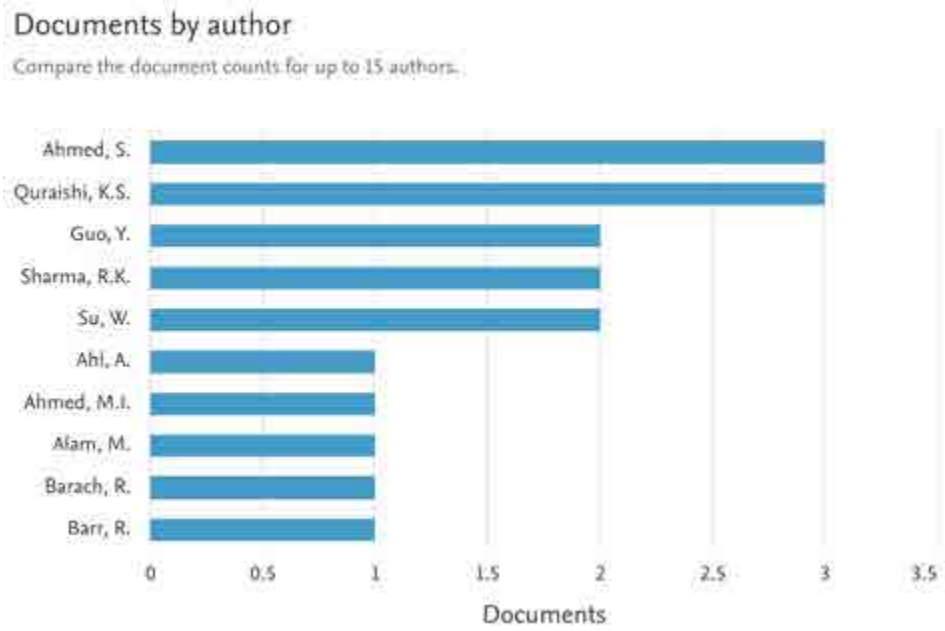

Figure 5: Leading authors on rooftop solar adoption research

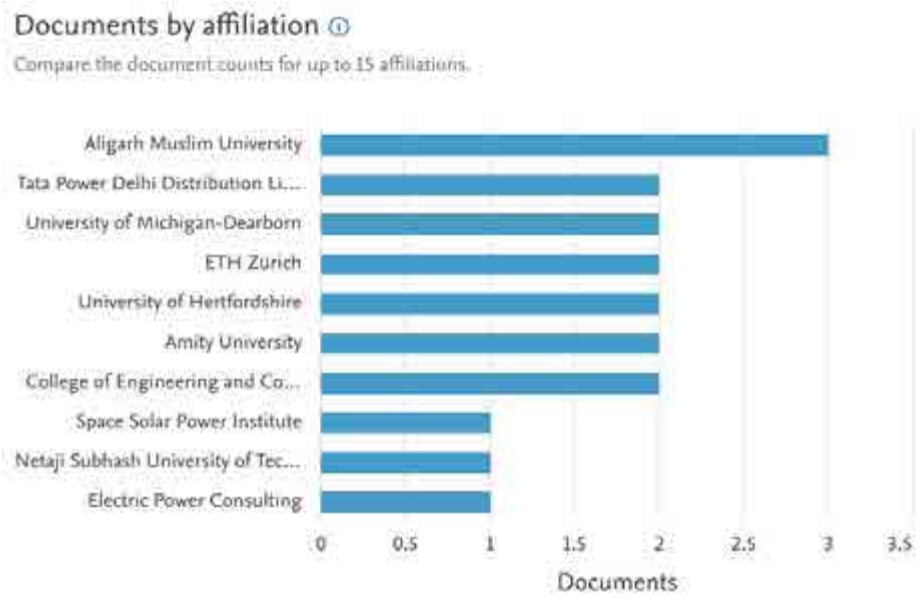

Figure 6: Affiliations of leading authors

f. Leading Countries

Figure 7 below reveals the world's top 10 countries leading the research activities of rooftop solar adoption. India and the United States contributed about 67 percent of the global publications till 2023 suggesting that these two countries play a key role in the advancement of on rooftop solar adoption research. India is the leading country with 16 publications followed by 07 publications by the United States. Australia and the United Kingdom have 04 publications each while Switzerland has 03 research documents. All the other countries have 01 publications each in the area of rooftop solar adoption research.

g. Leading funding agencies

The records on Scopus database also reveal the major funding agencies who have supported research on rooftop solar adoption. It can be observed that the Ministry of New and Renewable Energy, India has funded 02 research projects and is the top funding agency. Figure 8 shows all the other funding agencies who have financed 01 projects each. Names of the funding agencies are shown in Figure 8 below.

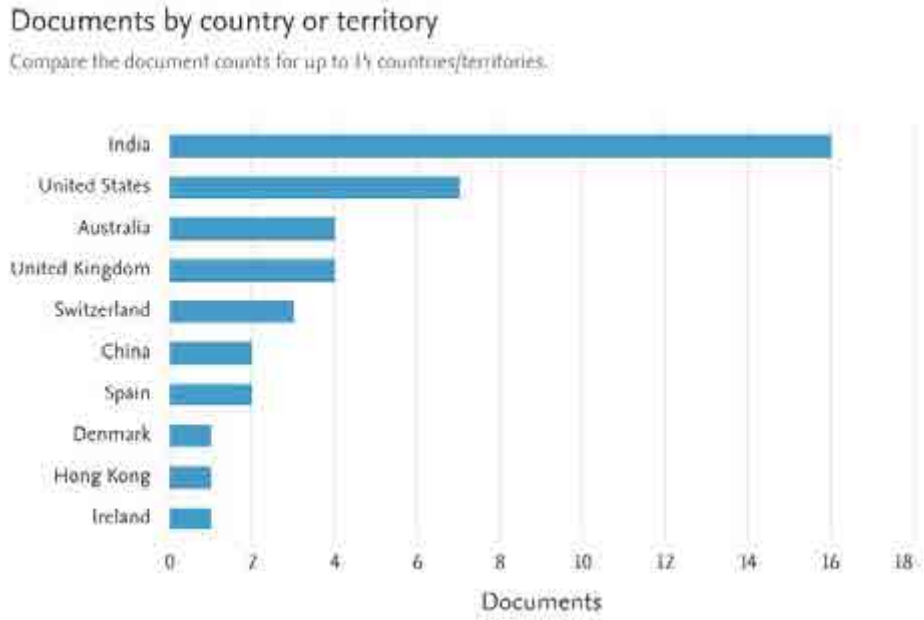

Figure 7: Leading Countries of rooftop solar adoption research

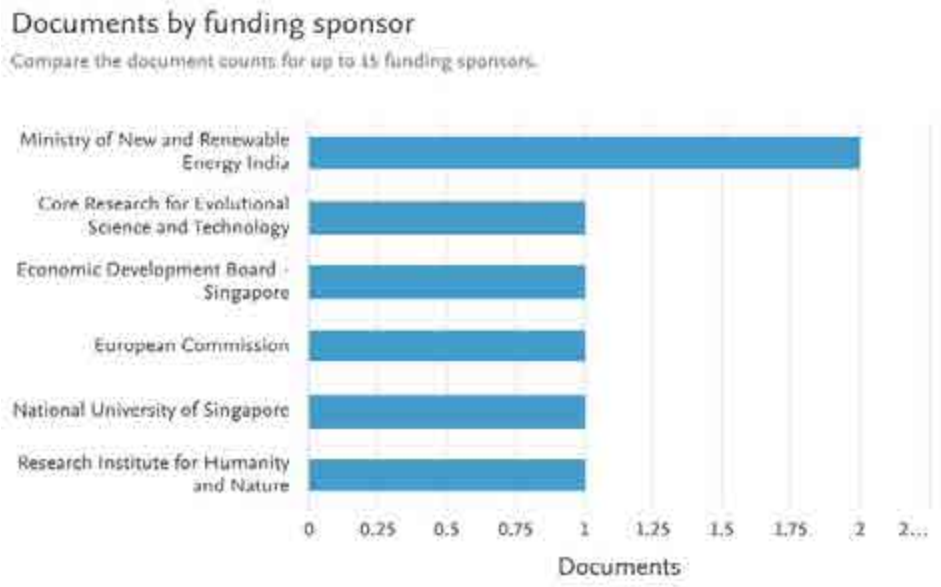

Figure 8: Leading funding agencies

Scientific mapping using VOSviewer

a. Citation analysis

A citation analysis was done from the Scopus database to evaluate the past impactful publications on RSPV adoption research. The search threshold was set to published documents which were cited at least once. The result showed 25 documents out of the 34 documents which met the above criteria. The top 05 documents with the highest citations are Mcguigan (2012) having 406 citations, Guo (2016) - 178 citations, Chen (2012) - 80 citations, Gautam (2015) - 70 citations and Kobasi (2020) - 59 citations respectively. The network visualisation of the citation analysis is presented in Figure 9.

b. Co-word analysis

The co-word analysis gathered all the keywords from the same database. For each of the keywords, the total strength of the co-occurence links with other keywords was produced. Results show that there are 04 notable clusters derived from the co-occurrence mapping. It is interesting to observe that out of the 499 keywords, 59 words met the minimum threshold when the number of occurrences of a keyword was set to 02. Solar energy with 10 occurrences, 47 links and having a total link strength (TLS) of 76 tops the database. Roofs (08 occurrences, 34 links and having a TLS of 45, renewable energy (05 occurrences, 38 links and having TLS of 52 and investment (04 occurrences, 24 links and having a total link strength of 31) are the other top four co-occurred keywords. All the 59 keywords have a combined total link strength of 589.

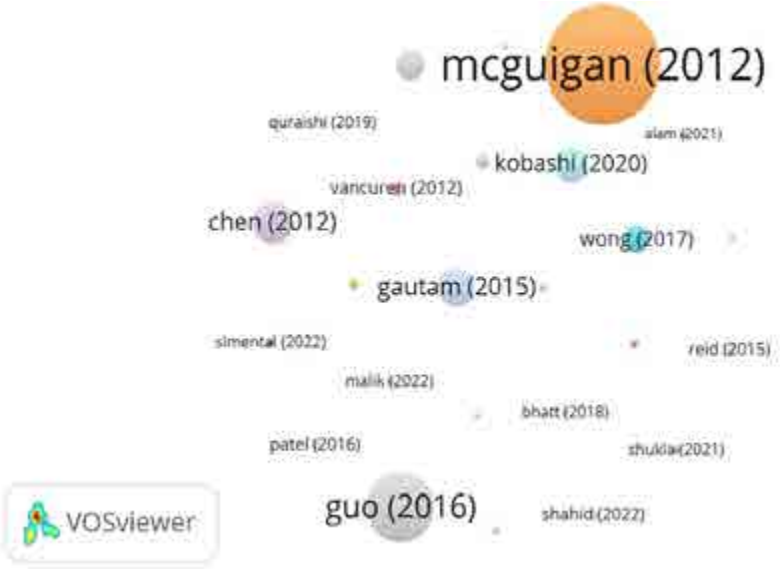

Figure 9: Publications cited at least once

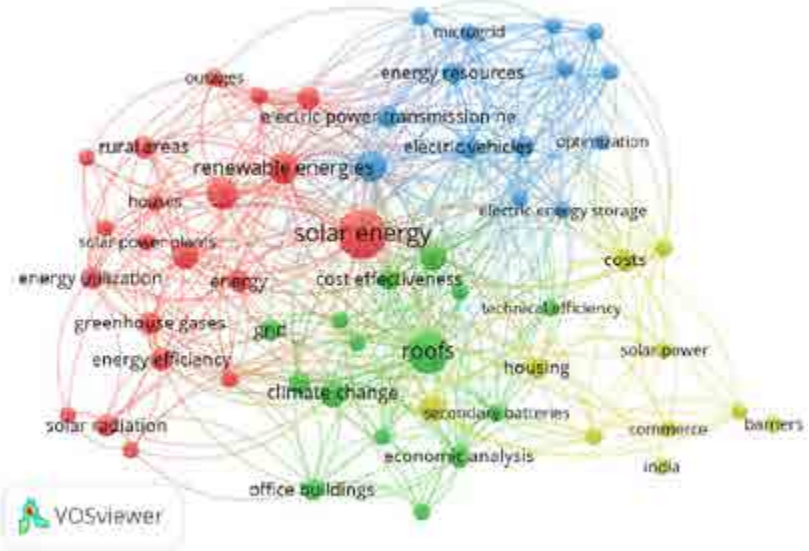

Figure 10: Network Visualisation of the co-occurence of keywords

Discussion and Conclusion

The present bibliometric analysis adopted a two-way approach to obtain an overview of knowledge of the current and future direction in the adoption of rooftop solar PV systems research based on Scopus database publications. The scopus analysis tool and the VOSviewer software tool was used to perform scientific mapping of the search database. A co-citation and co-word analysis filled the literature gap to a large extent while identifying critical pointers for future research. By limiting the search to "rooftop solar adoption" in article title, abstract, and keywords, the search results may not encompass all studies pertaining to this area that are available on Scopus database. For example, the results on Web of Science search has a feature called 'hot paper' which automatically shows the most popular articles in the field. This feature is lacking on Scopus. It is better to make a Bibliometric analysis by using and comparing multiple data sources such as Sciencedirect,Web of Science, EBSCO etc. in order to have a comprehensive understanding of the field and better generalisation. Future research should focus on important issues relating to policy formulation and implementation, infrastructure and institutional capacity building for recycling, managing challenges like creating awareness among consumers about the system, and building a skilled workforce for a smooth adoption of solar PV systems.

References

Abbas, A. F., Jusoh, A. B., Mas'od, A., & Ali, J. (2020). Bibliometric analysis of global research trends on electronic word of mouth using Scopus database. Journal of Critical Reviews, 7(16), 405-412.

Abbasi, K. R., Shahbaz, M., Zhang, J., Irfan, M., & Alvarado, R. (2022). Analyze the environmental sustainability factors of China: The role of fossil fuel energy and renewable energy. Renewable Energy, 187, 390-402.

Abbas, A. F., Jusoh, A. B., Mas'od, A., & Ali, J. (2020). Bibliometric analysis of global research trends on electronic word of mouth using Scopus database. Journal of Critical Reviews, 7(16), 405-412.

A. Kastrin, D. Hristovski, (2021). Scientometric analysis and knowledge mapping of literature-based discovery (1986–2020), Scientometrics 126 (2) 1415– 1451.

A.G. Olabi, M.A. Abdelkareem, (2022). Renewable energy and climate change, Renew. Sustain. Energy Rev. 158.

Benckendorff, P., & Zehrer, A. (2013). A network analysis of tourism research. Annals of Tourism Research, 43, 121-149.

Broadus, R. N. (1987). Toward a definition of "bibliometrics". Scientometrics, 12, 373-379.

De Bellis, N. (2009). Bibliometrics and citation analysis: from the science citation index to cybermetrics. scarecrow press.

E. Schulte, F. Scheller, D. Sloot, T. Bruckner, (2022). A meta-analysis of residential PV adoption: The important role of perceived benefits, intentions and antecedents in solar energy acceptance, Energy Res. Soc. Sci. 84.

Fauzi, M. A., Abidin, N. H. Z., Suki, N. M., & Budiea, A. M. A. (2023). Residential rooftop solar panel adoption behavior: Bibliometric analysis of the past and future trends. Renewable Energy Focus.

F. Wang, V. Nian, P.E. Campana, J. Jurasz, H. Li, L. Chen, J. Yan, (2022). Do 'green' data centres really have zero CO2 emissions?Sustainable Energy Technol Assess. 53.

J. Abreu, N. Wingartz, N. Hardy, (2019). New trends in solar: A comparative study assessing the attitudes towards the adoption of rooftop PV, Energy Policy 128 347–363.

J.L. Barnes, A.S. Krishen, A. Chan, (2022). Passive and active peer effects in the spatial diffusion of residential solar panels: A case study of the Las Vegas Valley, J.Clean. Prod. 363.

J. Sommerfeld, L. Buys, D. Vine, (2017). Residential consumers' experiences in the adoption and use of solar PV, Energy Policy 105 10–16.

M. Alipour, H. Salim, R.A. Stewart, O. Sahin, (2021). Residential solar photovoltaic adoption behaviour: End-to-end review of theories, methods and approaches, Renew. Energy 170 471–486.

M.D. Leonard, E.E. Michaelides, D.N. Michaelides, (2020). Energy storage needs for the substitution of fossil fuel power plants with renewables, Renew. Energy 145 951–962.

M. Irfan, Z.Y. Zhao, A. Rehman, I. Ozturk, H. Li, (2021). Consumers' intention-based influence factors of renewable energy adoption in Pakistan: a structural equation modeling approach, Environ. Sci. Pollut. Res. 28 (1) 432–445.

M. Raugei, P. Fullana-i-Palmer, V. Fthenakis, (2012). The energy return on energy investment (EROI) of photovoltaics: Methodology and comparisons with fossil

fuel life cycles, Energy Policy 45 576–582.

M. Tawalbeh, A. Al-Othman, F. Kafiah, E. Abdelsalam, F. Almomani, M. Alkasrawi, (2021). Environmental impacts of solar photovoltaic systems: A critical review of recent progress and future outlook, Sci. Total Environ. 759.

N.A. Ludin, N.I. Mustafa, M.M. Hanafiah, M.A. Ibrahim, M.A.M. Teridi, S. Sepeai, K. Sopian, (2018). Prospects of life cycle assessment of renewable energy from solar photovoltaic technologies: a review, Renew. Sustain. Energy Rev. 96 11–28. S. Dixit, Solar technologies and their implementations: A review, Mater. Today:. Proc. 28 (2020) 2137–2148.

N. Ojong, (2021). Solar home systems in south asia: examining adoption, energy consumption, and social practices, Sustainability 13 (14) 7754.

N. Rathore, N.L. Panwar, F. Yettou, A. Gama, (2021). A comprehensive review of different types of solar photovoltaic cells and their applications, Int. J. Ambient Energy 42 (10) 1200–1217.

P. Choudhary, R.K. Srivastava, (2019). Sustainability perspectives-a review for solar photovoltaic trends and growth opportunities, J. Clean. Prod. 227 589– 612.

S. Akter, K. Bagchi, (2021). Is off-grid residential solar power inclusive? Solar power adoption, energy poverty, and social inequality in India, Energy Res. Soc. Sci. 82.

S. Kahng, H. Yoo, J.H. Kim, (2020). Recent advances in earth-abundant photocatalyst materials for solar H2 production, Adv. Powder Technol. 31 (1) 11–28.

Van Raan, A. F. J. (2005). For Your Citations Only? Hot Topics in Bibliometric Analysis. Measurement:Interdisciplinary Research & Perspective, 3(1), 50–62. DOI:10.1207/s15366359mea0301_7.

X. Yang, J. Pang, F. Teng, R. Gong, C. Springer, (2021). The environmental co-benefit and economic impact of China's low-carbon pathways: Evidence from linking bottom-up and top-down models, Renew. Sustain. Energy Rev. 136.

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