

Analysis of Scientific Publications on Solar Water Heating Collectors

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Abstract

This study presents a bibliometric analysis of research on flat-plate solar water heater collectors based on the Scopus database from 2000 to 2025. A total of 937 publications were identified, with the majority being journal articles (65.1%) and conference papers (28.1%). The research predominantly falls under Energy (35.5%) and Engineering (29.1%), highlighting the technological and scientific interest in this field. The international collaboration network indicates that India and the UK (5 studies), as well as Iran and Malaysia (3 studies), have the most active partnerships. India, China, the USA, Iraq, and Saudi Arabia also contribute significantly to global research cooperation. These findings emphasize the growing attention toward solar water heating technologies and the strong collaboration between researchers in leading countries. This study provides insights into publication trends and interdisciplinary contributions, offering a foundation for future research directions in sustainable energy applications.

Keywords: *Flat-plate solar collector, Bibliometric analysis, Renewable energy, international collaboration, Scopus database*

1. Introduction

The current global trend is toward solar energy heating [1–5], cooling [6], hydrogen energy [7–10], and especially water solutions [11]. Solar water heating (SWH) collectors have gained significant attention as an efficient and sustainable solution for harnessing solar energy to provide thermal energy for residential, commercial, and industrial applications [12]. The growing global demand for renewable energy technologies has led to extensive research on the optimization, efficiency improvement, and material advancements in SWH systems [13]. Various designs, such as flat-plate collectors (FPCs), evacuated tube collectors (ETCs), and concentrating solar collectors, have been studied to enhance thermal performance and reduce energy losses [14,15].

The analysis of scientific publications on SWH collectors provides valuable insights into recent advancements, performance evaluation techniques, and key challenges in this field. Researchers have focused on improving the heat transfer characteristics of collectors through advanced materials, phase change materials (PCMs), and nanofluid applications [16,17]. Computational models, including computational fluid dynamics (CFD) and artificial intelligence (AI)-based optimization, have also been employed to enhance the design and efficiency of SWH systems [18]. Furthermore, techno-economic and environmental assessments are crucial in determining the feasibility and sustainability of these systems [19].

This review aims to systematically analyze the trends in scientific publications on SWH collectors, highlighting key areas of development, emerging technologies, and future research directions. By examining recent studies, this analysis will contribute to a deeper understanding of the progress and challenges associated with solar water heating technologies.

2. Methodology

Scientific publications published using keywords such as << flat AND solar AND water AND heater AND collectors >> were identified from the international publication database, using the open platform of the Scopus database. At the same time, additional publications were identified using keywords such as << pcm AND flat AND solar AND water AND heater AND collectors >> to identify articles with a new approach (10/02/2025). Based on this collected data, the number of publications, countries and authors contributing to them, types and fields of publications were analyzed. Different types of solar water heating collectors, their advantages and disadvantages were identified. After that, a “Literature Analysis” was conducted on the selected articles. In the literature analysis, the scientific innovations and results of the articles were identified in the form of keywords, and gaps in scientific work were identified using the cosine similarity method.

3. Literature review

The data identified based on the open search of the Scopus database are presented in Figure 1. The

number of publications and the share of countries (in percent) of scientific works on flat solar water heating collectors from 2000 to 2025, identified by keywords such as << flat AND solar AND water AND heater And collectors >>, are presented. The bar chart shows the increasing trend of the number of publications over the years and the years 2000-2025 are considered, since most of the scientific research falls within this period. We can see that the number of articles has increased since 2000. After 2014, a significantly faster increase is observed [20]. The

pie chart in the figure below shows the distribution of publications by country. India is leading with 18.9% of publications. Other contributing countries include China (8.8%), the United States (5.4%), Iran (3.8%), the United Kingdom (3.7%), Italy (3%), Saudi Arabia (2.9%), and Egypt (2.8%), with the remaining countries accounting for 50.7%. A total of 933 papers on flat-plate solar water heater collectors have been published by countries and scientists around the world.

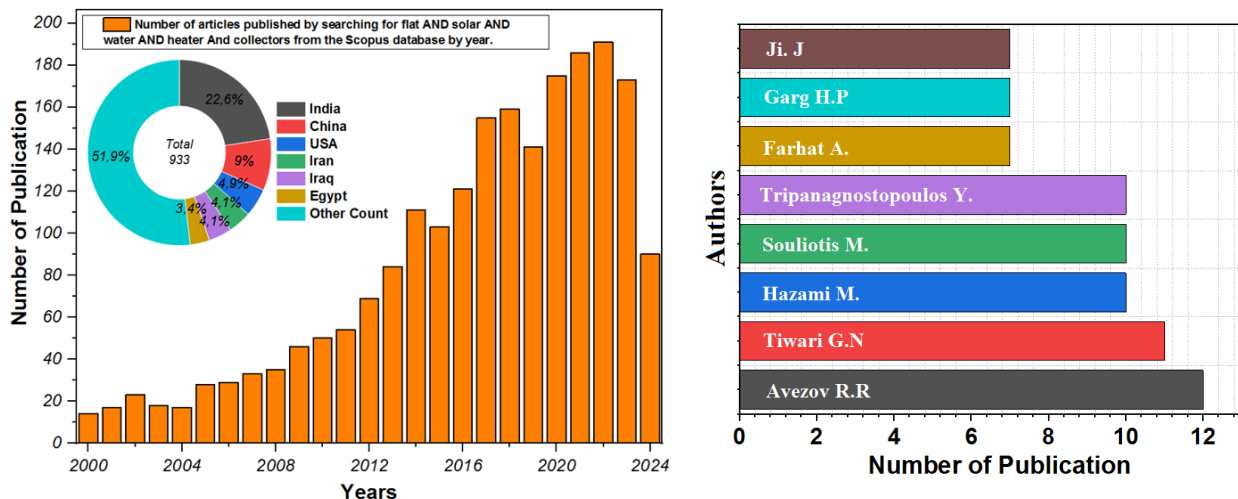


Fig. 1. Articles published in the Scopus database for flat solar water heater collectors by year and authors (2000-2024).

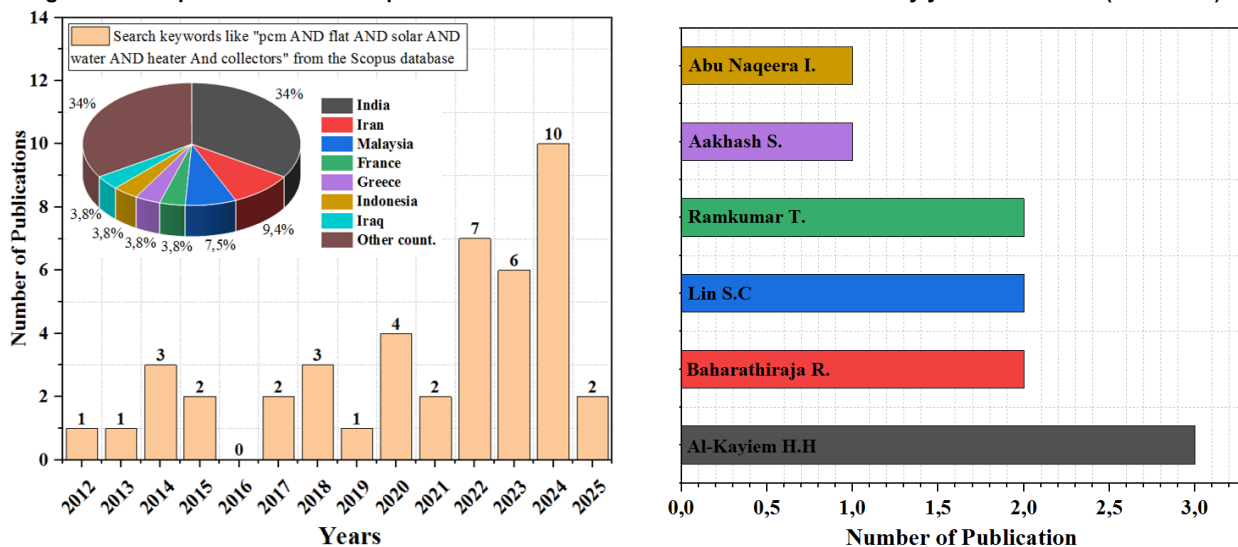


Fig. 2. Scientific publications of authors on the application of PCM in flat solar water heater collectors published in the Scopus database (2010-2025).

Fig. 1 illustrates the contributions of various authors to research on flat-plate solar water heating collectors. G.N. Tiwari leads the field with 19 publications, followed by the Uzbek scientist Avezov R.R. with 16 publications, the Chinese researcher Jiang Ji with 14 publications, M. Hazami with 13 publications, and Farhat A. with 12 publications. Additionally, notable contributions have been made by scholars such as E. Bellos, Chow T.T., Singh D.B., and Kalogirou S.A.

As illustrated in Figure 2, research on the integration of phase change materials (PCM) with solar water heating collectors has predominantly emerged since 2010. In this domain, India (34%), Iran (9.4%), and Malaysia (7.5%) lead

in scientific contributions. Among the most prolific researchers in this field, Al-Kayiem has published three articles, while Bharathiraja, Lin S.C, and Ramkumar have each contributed two articles, among others (as depicted in Figure 2).

The distribution of scientific publications related to flat-plate solar water heating collectors in the Scopus database (covering the period from 2000 to 2025) varies across publication types and scientific disciplines.

An analysis of publication types reveals that scientific articles dominate the field, accounting for 62.9% of the total publications. Conference papers follow, constituting 29.6% of the overall volume. Books and book chapters represent 4.5% and 1.9%, respectively. Additionally, review articles make up 1%, while conference reviews

account for 0.1%. These findings indicate that research in this field is primarily disseminated through scientific articles and conference proceedings.

A subject-based analysis provides the following insights: the energy sector holds the largest share (31%), followed by engineering (26.1%). Materials science (13%)

and environmental sciences (8.3%) also play a significant role. Other relevant fields include chemical engineering (6.2%), physics and astronomy (3.8%), mathematics (3.2%), computer science (3%), and chemistry (2.2%). Additional disciplines collectively account for 3.1% of the total publications (Figure 3).

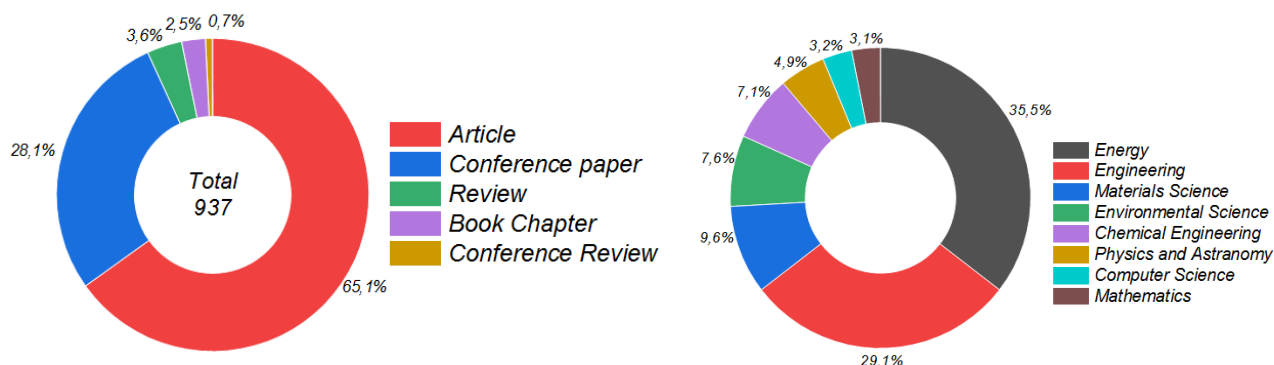


Fig. 3. Distribution of articles on flat-plate solar water heater collectors by type and industry in the Scopus database (2000-2025).

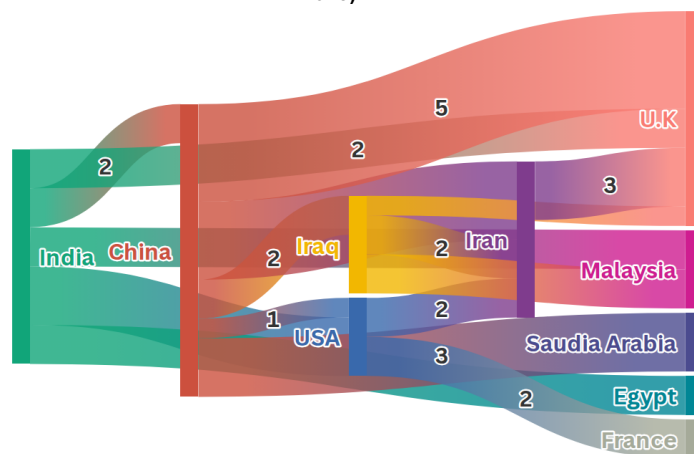


Fig. 4. International collaboration in Scopus publications on flat-plate solar water heater collectors (2000-2025).

This analysis indicates that scientific research on flat-plate solar water heating collectors is actively conducted in the fields of energy and engineering. Additionally, studies on this topic are also being carried out in disciplines such as materials science and environmental sciences. This suggests that the field is not only approached from an engineering perspective but is also closely linked to material selection, environmental considerations, and mathematical modeling across various scientific domains.

3. Conclusion

The analysis at this stage shows that scientific interest in PCM integrated flat plate solar collectors has increased in recent years. Especially after 2020, publications on this topic have increased sharply. India and Iran stand out as

leading countries in this direction. This indicates an increase in global scientific attention to aspects of the topic such as sustainable energy sources, thermal energy storage, and increasing the efficiency of solar heaters.

The number of scientific articles on flat plate solar water heater collectors is quite high (937). The largest number of articles are written in the fields of energy and engineering. India and the United Kingdom are the most active scientific partners on this topic. The research is mainly published in the form of articles and conference proceedings.

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