



# Bibliometric Analysis of Entrepreneurial Trends in the Energy Sector: A Focus on the Residential Electricity Market

Sara Bahrami\*, Seyed Reza Hejazi, Nasser Masoumi

Department of School of Entrepreneurship, University of Tehran, Tehran, Iran

## ABSTRACT

This research conducts a bibliometric analysis of energy entrepreneurship, focusing on the residential electricity sector and utilizing the Web of Science database to extract papers published in top-tier journals over the past decade. A comprehensive analysis of a total of 2,487 articles revealed a sharp 237% increase in publication numbers, along with over 37,000 citations, underscoring the significant attention this field is receiving. Additionally, tools like VOSviewer and CiteSpace are used to highlight the most relevant keywords and their relationships, as well as to recognize leading authors and countries in this research area. While China and the USA are the predominant countries in terms of study locations, the research has identified a need for further investigation in other countries, including Iran, Norway, and Pakistan. The research domains suggest that energy entrepreneurship, especially within the residential electricity market, encompasses engineering, business economics, and computer science, making it one of the most influential topics today.

**Keywords:** Entrepreneurship; Energy sector; Residential electrical energy; Bibliometric analysis

## INTRODUCTION

Entrepreneurship plays a key role in shaping economies, especially in developed or developing countries [1]. Analyzed at its core principle, entrepreneurship involves observing and investigating a market need and thinking, 'I can fill that gap' [2]. The word itself, derived from Latin and meaning "to take on," represents an attitude of tackling challenges prevalent in both small family businesses and rapidly expanding tech startups [3]. There are businesses that focus on merging profit with positive social change, and some large companies also house internal innovators, demonstrating that even extensive groups can adapt when necessary [4]. Given the rapidly changing world and the entrepreneurial spirit, technology is making the once-impossible now achievable. A great illustration is the energy sector; while it was once dominated by large corporations, now smaller businesses are stepping up to compete with them [5]. These new leaders aim to make energy available to everyone by utilizing advanced technology and a strong desire for sustainable and clean energies [6].

This change is extremely affecting the energy industry, not only by addressing the growing demand for energy but also by

introducing innovative job roles that deviate from the norm in these entrepreneurial ventures [7]. They also highlight a dedication to environmental care, which is crucial in light of the challenges posed by global warming. Merging economic progress with environmental responsibility offers two main advantages, including strengthening our financial position and supporting a healthier environment, goals worthy of our dedication and focus [8].

In contemplating the future, in which households play an active role in energizing their local communities and engaging in entrepreneurial ventures, one cannot help but ponder the intriguing complexities of this prospect [9]. To effectively navigate and understand the transformative shifts occurring within the entrepreneurial landscape of the energy sector, a robust set of analytical tools is essential. In this context, bibliometric analysis emerges as a pivotal methodology of principal significance. In its core essence, bibliometric analysis furnishes a quantitative lens through which to examine the vast quantity of academic literature [10]. Employing different metrics, makes this method able to clarify the intricate web of knowledge dissemination within a delimited research domain [11].

Several studies in existing literature have delved into

**Correspondence to:** Sara Bahrami, Department of School of Entrepreneurship, University of Tehran, Tehran, Iran, E-mail: sara.bahrami22@ut.ac.ir

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entrepreneurial tendencies within the energy sector. As highlighted in [12], there's an emerging perspective on entrepreneurship, one that emphasizes its "associative" nature. This particular study, focusing on mutual businesses in Wales' renewable energy scene, underscored a plausible inherent bond between sustainability and cooperative frameworks. The findings from this research suggest that meaningful progress in sustainability, especially in the context of renewable energy, might call for a refreshed perspective on entrepreneurship, leaning towards a mutualistic stance. Authors in [13], discussed the often-overlooked impact of the energy sector's expansion, specifically in the realm of shale, on small business entrepreneurship. Delving into the oil and gas boom in the US between 2001 and 2013, the study employs different methodologies to analyze its influence on self-employment. The findings suggest that growth in the oil and gas industry, in the long run, tends to overshadow or even diminish self-employment opportunities in other sectors, hinting at a potential "resource curse." Heiskanen et al. Explore the interplay between institutional entrepreneurship research and sustainable energy initiatives in [14]. The research seeks to understand the potential insights each domain can offer the other, by engaging in a collaborative inquiry with government-affiliated organizations championing sustainable energy. The results showed the value of institutional entrepreneurship concepts in refining the strategic and political aspects of energy transformation.

In the authors conducted a comparative entrepreneurial analysis of contemporary combined-cycle power technologies and forward-looking, high-efficiency oxy-fuel combustion cycles boasting zero emissions [15]. Through a thorough examination and comparison of various generation technologies and their economic ramifications, the authors charted the progression of these technologies in line with sustainable development. The research not only delves into the nuances of the globally recognized combined-cycle methodology but also presents a comprehensive economic model. In the research delves deep into sustainable entrepreneurship, grounding it in the context of sustainable development [16]. The study examines the factors influencing the transition from conventional to sustainable entrepreneurship, with a particular focus on Gujarat, a leading state in India for renewable energy potential. The findings emphasize that renewable energy entrepreneurs are driven by economic incentives, a commitment to the environment, and societal considerations.

While numerous studies have addressed this topic in the literature, uncertainties persist regarding the trends, research interests, and existing gaps. Bibliometrics offers researchers a comprehensive view of the nature, structure, and evolving patterns in their domain. This statistical analysis goes beyond mere numbers; it involves a deep dive into literature reviews, analyzing publication sources, identifying prolific authors, and assessing citation frequencies. It provides insights into not only the current state of research but also its potential future directions. In essence, bibliometrics serves as a compass, guiding us through the expansion and scope of specific research domains [17].

The aim of this study is to thoroughly understand the contemporary applications of entrepreneurship in the energy sector, with a particular focus on electrical energy within the household sector. Recognizing leading researchers, organizations, and institutions, as well as their collaborations and prevailing topics, is crucial. To achieve this, we intend to conduct a bibliometric analysis of pertinent papers published in the Web of Science between 2014

and 2023.

The structure of this paper is organized as follows: Section 2 presents a definition and taxonomy of entrepreneurship. Section 3 outlines the methodology used. Section 4 delves into the findings concerning entrepreneurship in the energy sector. Lastly, Section 5 offers the conclusion to the study.

### Entrepreneurship definition and taxonomy

Entrepreneurship is a multifaceted concept associated with the ability to improve the economy, develop technological innovations, and enable social transformation. Identifying opportunities plays a key role in this concept [18]. Allocating and mobilizing resources, creating value, and assuming associated risks are its other important pillars. Different taxonomies have been proposed for entrepreneurship. This section begins with a broad taxonomy as presented in Figure 1, then specifically focuses on energy entrepreneurship for a more detailed investigation (Figure 1).

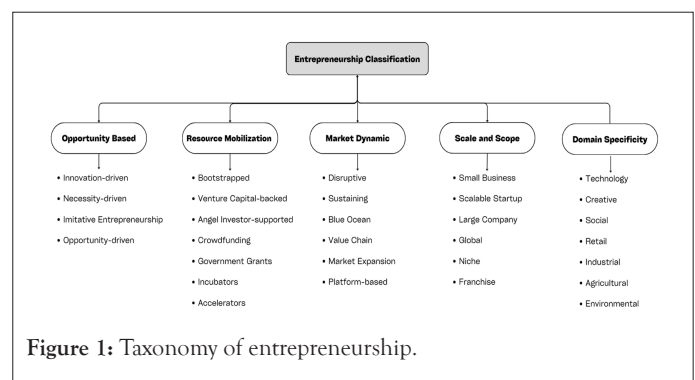


Figure 1: Taxonomy of entrepreneurship.

**Opportunity based:** Opportunity-based entrepreneurship identifies and exploits business opportunities due to their significant economic return. There are sub-categories including innovation-driven, imitative, and necessity-driven entrepreneurship [19]. The first focuses on the development of new products or services that introduce novel solutions, while the second involves the replication of existing ideas without significant changes in their nature. Finally, necessity-driven entrepreneurship occurs when individuals engage in innovative activities, often driven by a need for employment.

**Resource mobilization:** This category distinguishes entrepreneurial ventures based on their approaches and strategies for utilizing resources to address needs. These resources include financial capital, human talent, physical assets, technological resources, and intellectual property [20]. Bootstrapped entrepreneurship, a significant sub-category, refers to launching a business with minimal capital. In contrast, venture capital-backed entrepreneurship involves businesses that are scaled and grown with institutional investments. Angel investor-supported entrepreneurship is characterized by small-scale ventures that receive capital from wealthy individuals, often in exchange for ownership equity. Crowdfunding represents another category where individuals post their ideas online and receive modest contributions from a large group of people to support their business ventures [21]. Finally, there are ventures that are initiated or sustained with the help of government resources, which constitute yet another form of support for entrepreneurial endeavour.

**Market dynamic:** Market dynamic as a category within the taxonomy of entrepreneurship categorizes ventures based on

their type of interaction within the marketplace. Disruptive entrepreneurship implies businesses that fundamentally change the market while sustaining entrepreneurs aim to offer higher quality products or services within the current market framework [22]. Market expansion entrepreneurs detect and expand new markets for existing products while Blue-Ocean entrepreneurship tries to create a new market space.

**Scale and scope:** Entrepreneurship can be categorized based on the scale of the business, ranging from small businesses to large companies and global enterprises [23]. Niche entrepreneurs target a specific segment of a market by providing customized products or services, while franchise entrepreneurship involves duplicating a successful business model in different locations, replicating the exact nature and model [24]. Last but not least, scalable startup entrepreneurship aims to establish businesses that start small but are designed to grow rapidly and scale significantly [25].

**Domain specificity:** The classification by domain specificity categorizes entrepreneurial ventures based on the specific field or industry in which they operate, encompassing areas such as technology, retail, social, service-based, industrial, agriculture, and environmental entrepreneurship [26]. This approach considers how the unique traits and conditions of each sector influence the nature of the entrepreneurial activities within it.

Entrepreneurship in the energy sector encompasses various categories within the previously outlined taxonomies. The precise classification depends on several factors, including the nature of the business, the goals and objectives, the target market, and the type of innovation and value creation [27]. When the primary focus is on developing new technologies, the business is categorized as innovation-driven entrepreneurship, whereas if the venture addresses issues related to air pollution or climate change, it is termed environmental entrepreneurship. However, there is a great overlap between social and environmental entrepreneurship in the energy sector since aside from energy poverty, clean energy and reducing greenhouse gasses is the primary goal in both categories [28].

Some novel ideas in the energy sector, such as proposals for decentralized energy systems, blockchain-based peer-to-peer energy trading platforms, or innovative dynamic pricing models, have the potential to revolutionize the traditional energy market [29]. Consequently, they are categorized as disruptive entrepreneurship. However, if the focus is targeted at a specific segment of the energy sector, such as the residential electricity system, then the type of entrepreneurship becomes sector specific. On the other hand, many start-ups in the energy sector act as sustaining entrepreneurs; they make incremental enhancements to existing technologies or services and are thus categorized as sustaining entrepreneurship.

## MATERIALS AND METHODS

This section aims to clarify the method of conducting a bibliometric analysis to systematically study, evaluate, monitor and visualize the structure of the current trends in the energy sector entrepreneurial, specifically focusing on the residential electricity market. Foundational principles and publication analysis are two most important segment of bibliometric methods. Within the first category, researchers outline methods designed to minimize potential errors in the exploration process. This includes developing strategies for the effective use of search engines to locate relevant prior studies. On the other hand,

publication analysis delves into assessing different aspects of literature, including Impact Factor (IF), citation count, publisher credibility, and the origin country of the research.

Citation analysis and content analysis are two remarkably foremost techniques in the bibliometric methods [30]. The former is an effective tool for recognizing key literature, top tier journals, and the countries that contribute to a particular field. Moreover, it sheds light on the complex links between cited and citing papers, highlighting how research impacts and interacts within the academic community [31].

**The methodology of this research is outlined in the following sections**

**Data collection tool:** The required data for conducting the analysis are available in multiple academic databases, including Web of Science, Scopus, and Google Scholar. However, this research has extracted its data from Web of Science the most famous tool for bibliometrics analysis due to its great features such as containing 12,000 journal titles ranging from 1900 to the present, coverage of 45 different languages, and the provision of exceptional search tools that allow for the refinement of searches by author, country of origin, article type, institution, source title, subject area, funding information, and more.

The data extraction step was conducted using a combination of keywords related to energy entrepreneurship ("entrepreneurship," "startup," "new venture") and the energy sector ("energy," "residential electricity," "electricity market," "renewable energy," "sustainable energy"). The time frame for the search was set from 2013 to the 2023, reflecting the growing interest in this area over the past decade.

**Inclusion and exclusion criteria:** This research includes journal papers published in top-tier peer-reviewed journals which their focus is on the energy sector. Additionally, just articles written in English are included. Excluded from the analysis are all conference proceedings, books and book chapters and non-peer-reviewed articles.

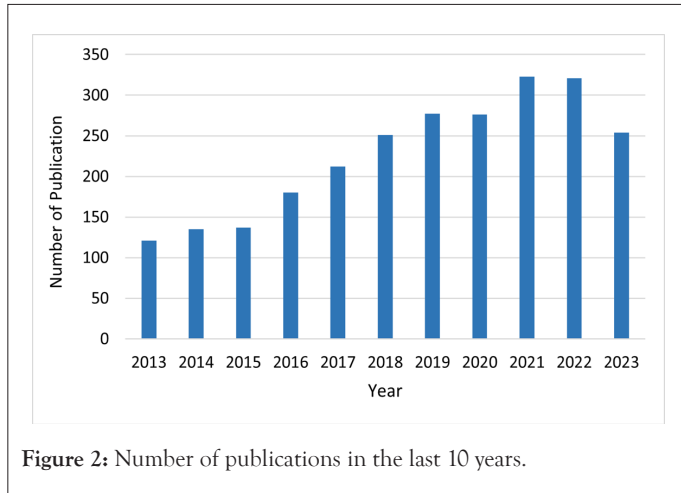
**Data analysis:** Different tools, such as "VOSviewer" and "CiteSpace," are utilized to perform co-citation and co-word analyses, as well as network analysis. These methods are employed to identify the most influential authors, journals, institutions, and countries in the field of energy entrepreneurship, with a particular focus on the residential electricity sector. Moreover, these tools enable us to trace the trajectory of research trends, thereby illustrating the evolution of topics within energy entrepreneurship over time. Ultimately, a range of key bibliometric indicators, including the number of publications, citations, h-index, and journal impact factors, are examined to assess the impact and quality of research in this field.

## RESULTS AND DISCUSSION

### Findings

This section presents the findings from a bibliometric analysis on entrepreneurial trends in the energy sector, with a specific focus on the residential electricity sector. The results are output of a precise investigation on collected data from research of high quality, offering a foundation for researchers seeking to advance scholarship in this field. The findings are categorized into six distinct subsections including publication year, citations, leading authors, research domains, leading countries, and the frequency of keywords.

**Publication year:** Discovering the trend in the number of publications over the last ten years is the first crucial step in understanding research interest in the field. As Figure 2 illustrates, the number of papers published on energy entrepreneurship has been steadily increasing over the last decade, starting from 135 in 2013 to 321 by the end of 2022, indicating a 237% rise in interest. This escalation in research attention indicates that this topic is one of the most dynamic areas in research (Figure 2).



**Citation and the most cited papers:** Citations analysis is a robust method for assessing the impact of publications beyond their quantity [32]. It reveals the influence and significance of research by tracking the frequency of citations in the literature. This approach offers a deeper understanding of academic merit and the proliferation of knowledge within the field. Over the past ten years, the total number of citations for 2,487 papers stands at 37,959, with an average of 15.26 citations per document and an h-index of 82. The substantial number of citations also underscores the high level of research interest in this topic. Table 1 shows the top 10 research in terms of the number of citations (Table 1).

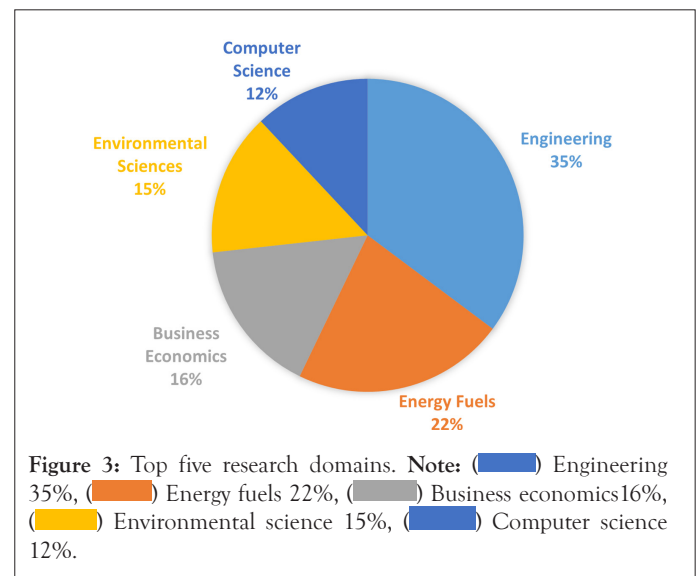
**Table 1:** The substantial number of citations also underscores the high level of research interests.

An example of a column heading	#Citation
Blockchain technology in the energy sector: A systematic review of challenges and opportunities.	912
CalcHEP 3.4 for collider physics within and beyond the standard model.	683
Three frames for innovation policy: R&D, systems of innovation and transformative change.	593
Sustainable innovation, business models and economic performance: An overview.	570
The interdisciplinary nature of SOIL.	434
Financing Innovation: Evidence from R&D grants.	318
A comprehensive review of PBI-based high temperature PEM fuel cells.	283
Unlocking value for a circular economy through 3D printing: A research agenda.	249
Sustainable business models: A review.	230
Recent advances and challenges in the anode architecture and their modifications for the applications of microbial fuel cells.	217

**Leading authors:** Knowing the leading authors offers a range of benefits, including networking opportunities, guidance in research directions, possibilities for benchmarking, and openings for collaboration [33]. The results show that Li Y, Wang Y, and Zhang L are the leading authors, having published 14, 13, and 12 papers, respectively. Gao Y and Li X are also notable, each having published a double-digit number of papers.

**Research domains:** The main advantage of understanding research domains in bibliometric analysis is identifying and tracking research trends over time which helps to prioritize areas that are garnering significant academic interest [34]. This provides strategic focus and the informed allocation of funds. Additionally, it allows researchers to benchmark their work against the dominant themes within these domains. Figure 3 demonstrates the top five domains in the field of energy entrepreneurship. The results indicate that Engineering is the most dominant field, followed by Energy Fuels, Business, Environmental Science, and Computer Science. Additionally, the data shows that energy entrepreneurship, with a focus on the residential electricity market, encompasses all top five categories, making the study one of the most dominant topics.

**Leading countries:** There are two major benefits to identifying the leading countries in a research field. The first is recognizing the locations of funding agencies to understand where significant research is being conducted and where to direct investments for maximum impact and collaboration [35]. Additionally, it highlights the relevance of the research to the authors' current location. The results indicate that while China and the USA are the two leading countries, with a significant margin over others, there is a considerable need for research in countries such as Iran, Norway, and Pakistan (Figure 3 and Table 2).



**Table 2:** The major benefits to identifying the leading countries in a research field.

Countries/regions	Record count	% of 2,487
Peoples r China	609	24.487
USA	450	18.094
England	167	6.715
Germany	136	5.468
India	124	4.986



Italy	109	4.383
Netherlands	98	3.94
Spain	96	3.86
Canada	86	3.458
France	68	2.734
Japan	66	2.654
South Korea	56	2.252
Australia	53	2.131
Switzerland	53	2.131
Poland	52	2.091
Russia	51	2.051
Sweden	48	1.93
Brazil	46	1.85
Finland	44	1.769
Denmark	42	1.689
Taiwan	41	1.649
Iran	40	1.608
Malaysia	39	1.568
Norway	38	1.528
Pakistan	35	1.407

**Keyword frequency:** One of the most effective approaches to uncovering relationships between different domains within a research topic, as well as identifying gaps and trends, is to study the frequency of keywords in previously published literature [36]. A total of 1,501 keywords have been derived from 8,934 that appear more than 10 times across all documents. These keywords are categorized into four major clusters, with "Startup," "New Venture," "Company," and "Electricity Market" being the most repeated keywords in each cluster, respectively. Figure 4 further provides an in-depth understanding of the connections between and within different clusters through a word map based on content analysis of the publications (Figure 4).

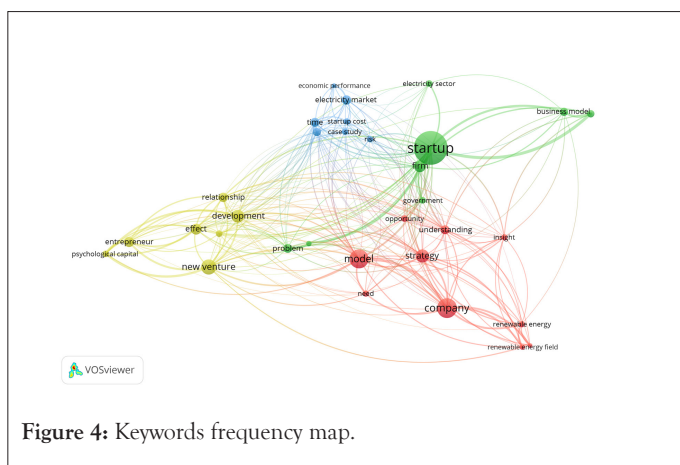


Figure 4: Keywords frequency map.

## CONCLUSION

This research conducted a bibliometric analysis on entrepreneurial trends in the energy sector, specifically focusing on the residential electricity market. After presenting various possible taxonomies of entrepreneurship, Web of Science was selected as the search

engine for extracting all the required information to perform the analysis. Subsequently, relevant keywords were meticulously chosen based on a comprehensive literature review previously conducted on the topic. The extraction was confined to top-tier journals over the past decade, ultimately yielding 2,487 documents.

The results indicate a 237% increase in the number of publications over the past decade, with the total number of citations reaching 37,959, an average of 15.26 citations per document, and an h-index of 82. These findings also reveal rapidly growing research interest and scholarly output in this field. Additionally, the research identifies leading authors and countries, providing valuable insights to enhance collaboration and pinpoint experts for potential partnerships, knowledge exchange, and gap identification. Moreover, the domain analysis suggests a strong interdisciplinary approach, encompassing engineering, energy fuels, business, environmental sciences, and computer science. Furthermore, the keyword frequency analysis offers insights into the principal topics and potential gaps within the literature.

This analysis demonstrates that there is significant research interest in the topic of energy entrepreneurship, especially in the electricity market. It has shown that comprehensive research is required to investigate and study this topic, considering all aspects of engineering, entrepreneurship, and computer science, with a focus on marketing, business models, and environmental challenges. This need is further felt in countries where fewer studies have been conducted, such as Iran, Norway, and Pakistan.

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