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THE SCENARIO MAPPING OF STARTUPS IN THE ENERGY SECTOR AND THEIR PERSPECTIVES FOR DISSEMINATING SUSTAINABILITY: A SYSTEMATIC LITERATURE REVIEW

VIRGINIA THOMASI
Mestre em Engenharia de Produção
Universidade Federal de Santa Maria (UFSM)
virginiathomasi.br@gmail.com
ORCID: 0000-0002-6678-3795
ALESSANDRA SCHOPF DA SILVEIRA
Mestre em Engenharia de Produção
Universidade Federal de Santa Maria (UFSM)
alessandra.schopf@gmail.com
ORCID: 0000-0002-3795-5746
LUCAS VEIGA AVILA
Doutor em Administração
Universidade Federal de Santa Maria (UFSM)
lucas.avila@ufsm.br
ORCID: 0000-0003-1502-258X
JULIO CEZAR MAIRESSE SILUK
Doutor em Engenharia de Produção
Universidade Federal de Santa Maria (UFSM)
jsiluk@ufsm.br
ORCID: 0000-0001-6755-7186

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UNIVERSIDADE FEDERAL DE SANTA CATARINA (UFSC)

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THE SCENARIO MAPPING OF STARTUPS IN THE ENERGY SECTOR AND THEIR PERSPECTIVES FOR DISSEMINATING SUSTAINABILITY: A SYSTEMATIC LITERATURE

Abstract

The startups can promote a change in business models, market segmentation, and even products and services offered in the sector. Unlike startups in other sectors, an energy startup demands a larger number of resources, even at the beginning of its operations, since it is usually associated with physical assets, which are more complex and costly to scale than business models based on data. In reviewing the literature, the literature lacks studies focused on startups in the energy sector. **Goal:** With this, the objective of this study was to identify through a literature mapping what is the scenario of startups in the energy market and what are the market perspectives in the dissemination of sustainable development. **Design | Methodology | Approach:** To reach the objective, a literature mapping was carried out using the VOSviewer software to build the analyses and understand the perspectives. It was verified that the theme is growing, but still needs more research, especially focusing on energy startups, the energy market, and sustainability. **Results:** It is noteworthy that when understanding the perspectives of the energy sector for the diffusion of sustainability, 12 trends were identified, which are not only theoretical contributions of this paper but also practical contributions for the diffusion of the sector in what involves startup and sustainability.

Keywords: Energy Startups, Energy Market, Sustainability, Renewable Sources, Energy Sector.

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1. Introduction

The economics, population growth, and climate change continually reshape the evolutionary path of many processes. Globalization and urbanization not only foster the growth of environmental impacts, but also increase the demand on resources for sustenance and growth. These factors cause increased greenhouse gas emissions (Valencia, Zhang, & Chang, 2022), depletion of fossil resources, and consequently global warming caused by conventional energy consumption (de Sousa, Vonortas, Santos, & de Toledo Filho, 2016). And, among the sectors that will have their structures substantially altered by the global attempt to contain the increase in the effects of emissions is the energy sector (Mendonça, 2018).

In the energy sector there is a process of transformational change focused on energy generating sources, predominantly based on fossil fuels, to a matrix that considers in a larger scale renewable source (Livieratos & Lepeniotis, 2017). In this sense of energy transition, the role of startups and the innovations developed by them can promote a radical change in business models, market segmentation, and even products and services offered in the sector (Livieratos & Lepeniotis, 2017; Siota & Prats, 2020). Energy startups are active in the energy generation, transmission, distribution, or trading chain. They are also active in an adjacent chain where innovations can affect future energy supply or demand, such as energy efficiency initiatives, electric or hybrid cars, or advanced stationary batteries (Mendonça, 2018).

From an academic point of view, studies such as that of Gupta et al. (2020) (Gupta, Fernandez-Crehuet, Hanne, & Telesko, 2020) conducted an analysis of the state of the art of requirements engineering research in the context of energy startups. Melegati et al. (2021)

International Journal of Knowledge Engineering and Management,
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(Melegati, Guerra, & Wang, 2021) understood through a review of the literature on the practices proposed by startup professionals to deal with hypotheses in the software startup scenario. It can be observed that research integrates technology and communication related to startups, thus there is a lack of studies focused on startups in the energy sector. Thus, the objective of this study is to identify by means of a systematic literature review the mapping of the scenario of startups in the energy market and to present the market perspectives in the diffusion of sustainable development.

This study is divided into five sections. The second section presents the concepts related to startups in the energy and sustainability market. The third section presents the methodologies used to conduct the study. The fourth section presents the results and discussions, and finally the fifth section presents the conclusion of the study.

2. The energy sector and the role of startups

With the disorder and crisis, we are going through, the energy market has remained buoyant, keeping pace with the global situation and adjusting supply and demand. Global investment in energy should total an average of US$ 1.9 trillion by 2021, and investments in renewable sources should triple by the year 2030 to keep up with the goals of the International Energy Agency (IEA, 2021).

According to the National Energy Balance made by the Energy Research Company (EPE, 2021), by the year 2020 the total energy available in Brazil reached 287.6 Mtoe and the Brazilian energy matrix remained at a higher renewable level compared to other countries. The same report evaluates that there was a retraction in the supply of non-renewable sources such as oil, natural gas, and coal because of the COVID-19 pandemic, which contributed to obtain a high percentage of renewability of the matrix.

International Journal of Knowledge Engineering and Management,
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The energy sector plays a key role in the country's economic growth and the quality of life of the population. However, meeting the energy demand requires more than just increasing production, it is necessary to invest in new sources of clean energy and in more efficient processes such as energy transformation, transportation, storage, and distribution (Mendonça, 2018).When it comes to the Brazilian energy sector, it is in a scenario in which its modernization and updating is required to meet the needs of the social body.

Energy startups have the possibility of leveraging this modernization process, however, given the high investments, there is a need for mediation to encourage the approach of startups to companies in the energy sector.. And, in this context, if energy startups have innovation practices in their essence, they can motivate in such a change, which leads to a change in the organizational environment of the energy sector (Mazzocchi, 2014) that will propitiate the modernization of the sector to adapt to the transformation context.

Startup is a company designed to find a scalable and repeatable business model with accelerated growth, that is, it has a business model format that allows the company to grow a lot and in a short time (RIES, 2012). Energy startups can also be characterized by their size or size, where they are defined as small companies with high growth prospects (Jane, Wu, & Luther, 2014), by their entrepreneurial organizational culture, by their focus on technological innovations (Sharif and Tang, 2014), by having more chances to be successful, by their short time of existence (Moroni, Arruda, & Araujo, 2015), and by their high level of uncertainty or risk (RIES, 2012).

An energy startup is a company that operates connected to the chain of generation, transmission, distribution, or commercialization of energy. Also considered as such is a company that operates in an adjacent chain whose innovations could significantly affect future energy supply or demand, for example, energy efficiency initiatives, electric cars, or advanced stationary batteries. The interaction of startups with the energy sector, enables an

International Journal of Knowledge Engineering and Management,
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• DOI: 1029327 •

acceleration towards increasing efficiency, reducing losses, and improving the quality of infrastructure for society and industry, considering the reduction of environmental impacts (Mendonça, 2018).

Unlike startups in other sectors, an energy startup demands a greater number of resources, even at the beginning of its operations, since they are usually associated with physical assets, which are more complex and costly to scale than data-based business models (Livieratos & Lepeniotis, 2017). Another important characteristic is the maturity period of energy startups, as by virtue of the potential for business scalability they tend to have potentially longer business cycles. The need for patient capital is a key issue for the success of energy startups (West, 2014).

2.1 Sustainable development in the energy sector

There is a need to reduce the speed of resource depletion and produce an alternative means for the demands in different sectors of science and technology. To meet the potential needs for energy production or secondary raw material production, solid resources can be the main source (Z. Zhang et al., 2022). In this context, there is a strong performance of circular economy and sustainable development. The performance of a circular economy can be measured through indicators that influence economic development such as social behavior, sustainable resource management, and business operations (Lieder & Rashid, 2016).

One beneficial practice for solid waste disposal and decomposition is recycling. Products can be recycled and reprocessed through physical or biological means (Tomić & Schneider, 2020). The heat from the contents obtained in reprocessing can generate electricity (Z. Zhang et al., 2022). In developing countries, it is common for per capita energy consumption to be lower than in developed countries, because these countries are in a phase of

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development and expansion of the production of goods and services, as well as reduction of inequalities to energy access (Simas & Pacca, 2013). Nascimento et al. (2012) (Nascimento, Mendonça, & Cunha, 2012) explain that the growing dependence on energy resources and issues related to climate change, pollution, and the economic impacts of fossil fuel dependence stimulate even more investments in renewable energy. Thus, the incorporation of renewable energy technologies and energy efficiency in development processes contributes to the efficient use of resources.

The United Nations (UN) has a list of 17 Sustainable Development Goals (SDGs). The goals are part of Agenda 2030, which stipulated that year as the date for achieving these objectives. According to IPEA (2021) (IPEA, 2021), there are some goals for sustainable development and one of them is accessible and clean energy, which seeks to ensure access to cheap, reliable, sustainable, and renewable energy for all. For these objectives the following goals are highlighted in Table 1.

Table 1 - United Nations and Brazil affordable and clean energy targets.

Goal	United Nations	Brazil	Indicators
7.1	By 2030, ensure universal, reliable, modern and affordable access to energy services	By 2030, ensure universal access.	7.1.1 - Percentage of population with access to electricity. 7.1.2 - Percentage of population with primary access to clean fuels and technologies.
7.2	By 2030, substantially increase the share of renewable energy in the global energy mix.	By 2030, keep the share of renewable energy in the national energy matrix high.	7.2.1 - Share of renewable energy in the Internal Energy Supply (IOE).
7.3	By 2030, double the global rate of improvement in energy efficiency.	By 2030, increase the rate of improvement in the energy efficiency of the Brazilian economy.	7.3.1 - Energy intensity measured in terms of primary energy and GDP.

International Journal of Knowledge Engineering and Management,
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7.4	By 2030, strengthen international cooperation to facilitate access to clean energy research and technologies, including renewable energy, energy efficiency, and advanced cleaner fossil fuel technologies, and promote investment in energy infrastructure and clean energy technologies.	By 2030, strengthen international cooperation.	7.4.1 - International financial flows to developing countries to support research and development in clean energy and renewable energy production, including hybrid systems.
7.5	By 2030, expand infrastructure and modernize technology for the provision of modern, sustainable energy services for all in developing countries, particularly the least developed countries, small island developing states, and landlocked developing countries, in accordance with their respective support programs.	By 2030, expand infrastructure and improve technology for the provision of modern, sustainable energy services for all.	7.5.1 - Investments in energy efficiency as a percentage of GDP and amount of foreign direct investment in financial transfers for infrastructure and technologies for sustainable development services.

Source: IPEA, 2021 (IPEA, 2021).

The targets and indicators are important because, as the demand for energy grows with the advancement of access to this good, it is necessary that it be from non-polluting sources. Therefore, SDG 7 highlights the importance of targets for the energy transition, leaving behind non-renewable and polluting sources. In addition, it calls for "special attention to the needs of the most vulnerable people and countries."

The UN SDG on clean energy is divided into smaller goals, always with 2030 as the horizon. One of them is to "ensure universal, reliable, modern, and affordable access to energy services."

3. Method

International Journal of Knowledge Engineering and Management,
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The research was conducted through bibliographic mapping. Bibliographic mapping tools allow for the processing of information produced by research, which facilitates the tracking of research developments and emerging trends (Sharifi, 2021). In comparison to peer reviews, which present a limited area of investigation, bibliographic tools examine unlimited amounts of publications (Wallin, 2005).

We conducted a bibliographic mapping of research on the landscape of startups in the energy market, to also present the market's outlook on the spread of sustainable development, as of December 2021, using the Scopus and Web of Science databases. To conduct the research, a protocol based on five stages was used.

The first step consisted in screening the databases using the following search string: (startup and ("energy market" or "electrical energy market" or energy) and sustainability). We did not define restrictions regarding language and year of publication. The type of search performed was advanced search, for which the search field used was the paper title, abstract, and keywords for a period comprising all papers until 2021. In the search performed, 28 papers were found in the Web of Science database and 45 papers in the Scopus database, totaling 73 papers.

In the second step of the protocol, an evaluation of the titles was performed to remove duplicate papers, using the metadata in Mendeley® software. Thus, from the 73 papers found, after removing the duplicates, 50 papers remained.

The third step of the protocol consisted in performing an exclusion analysis of the selected papers, evaluating the title, abstract, and keywords, and showing whether they were related to or relevant to the theme proposed in these papers. Thus, of the 50 papers evaluated, 14 were classified as relevant to the research, which was read in full.

The fourth step of the protocol is the performance of a Systematic Literature Review aimed at a systematic mapping of the startup scenario, carried out using the VOSviewer tool.

International Journal of Knowledge Engineering and Management,
Florianópolis, v. 12, n. 32, p. 24-68, 2023.
• ISSN 2316-6517 •
• DOI: 1029327 •

This tool is useful for creating bibliometric networks of journals, authors, publications, organizations, and countries (Sharifi, 2020). The networks are developed based on the analysis of co-author-ship, co-occurrence, citations, bibliographic coupling, and co-citation (van Eck & Waltman, 2010).

In the fifth stage, the framework was built, where the authors read the selected articles in full in order to identify trends or perspectives for the dissemination of sustainability in the energy sector.

Table 2 shows the results obtained in the execution of the described protocol.

Table 2 - Results for the proposed protocol.

Step	Description	Results
Search in Scopus and Web of Science using the defined string	(Start-up and ("energy market" or "electric power market" or energy) and sustainability)	73 papers (Scopus: 45; Web of Science: 28).
Exclusion of duplicated papers	Using Mendeley® software	Exclusion of 23 duplicate papers, leaving 50 papers.
Exclusion criteria	Evaluation of the title, abstract, and key words, and evidencing whether they are related to or relevant to the proposed theme.	Exclusion of 36 papers, leaving 14 papers for reading in full.
Systematic mapping of the literature	Using VOSviewer software to build bibliometric networks.	Bibliographic coupling analysis by authors, and keywords, co-citation analysis, countries, and sources (organizations).
Framework construction	Reading in full of the papers according to the research protocol.	From the analysis of the papers, extraction of trends/perspectives for diffusion of sustainability in the energy sector.

Source: Prepared by the authors (2021).

International Journal of Knowledge Engineering and Management,
Florianópolis, v. 12, n. 32, p. 24-68, 2023.
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• DOI: 1029327 •

This study, using the VOSviewer software, seeks to identify the main research groups related to startups in the energy market. And, based on the analysis of the papers, identify trends and perspectives to understand the diffusion of sustainability in the energy sector. The next section will address the results and discussions of this research.

4. Results and discussions

This section presents the results obtained in the bibliographic mapping. The analysis of these papers is divided into two sections, the first with the analysis of the most cited papers and keywords and the second section with the construction of a framework to outline the perspectives of the energy sector in the diffusion of sustainability.

4.1 The startup landscape in the energy sector

The results obtained in the diagnostic were performed using the VOSviewer software. The VOSviewer v.1.61 software for Microsoft Windows was used to build bibliometric diagrams for visualizing citations between journals and the co-occurrence of keywords in papers. The use of this software is valid because this program can work with large datasets and offers several options for analysis and investigations (Fahimnia, Sarkis, & Davarzani, 2015), creating easily interpreted images (maps) to aid in data analysis. VOSviewer shows the connection between related terms and authors by dividing them into groups, also called clusters. Each cluster is highlighted by a color and aggregates all items considered similar. The size of the circles created shows the number of occurrences of the item and the proximity between items reveal their degree of relatedness, i.e., the closer they are, the more related they are (van Eck & Waltman, 2010).

International Journal of Knowledge Engineering and Management,
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The first check performed consisted of the analysis of the type of citation in documents, that is, a mapping of the most cited papers from the collection selected in the systematic review was verified. For this evaluation, the documents with the most citations are highlighted in yellow, as shown in the scale attached in Figure 1. We can infer that the most cited papers are neither the oldest nor the most recent, and there is no tendency for the most published to be the most cited. That said, by noting the papers by Hosseini and Goudarzi (2019) (Hosseini & Goudarzi, 2019), El-Zonkoly (2015) (Amany El-Zonkoly, 2015), Ahlgren Ode and Lagerstedt Wadin (2019) (Ahlgren Ode & Lagerstedt Wadin, 2019), and Greer et al. (2020) (Greer, von Wirth, & Loorbach, 2020) as the largest circles, we recognize that the high number of citations relative to the others is due to their relevance.

Figure 1 - Bibliographic connection of authors.

Source: Prepared by the authors (2021).

International Journal of Knowledge Engineering and Management,
Florianópolis, v. 12, n. 32, p. 24-68, 2023.
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To detail the contribution of the most cited documents in the research, Table 3 highlights the most cited 14 documents on the topic, their characteristics, and their main contributions. By analyzing the publication's objectives and results, we can see that they all seek sustainable energy alternatives.

International Journal of Knowledge Engineering and Management,
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Table 3 - Analysis of the contributions and characteristics of the main papers obtained through the VOSviewer analysis.

Author	Title	Journal	Strings	Citations	Year	Main Contributions
(Hosseini & Goudarzi, 2019)	Design and CFD study of a hybrid vertical-axis wind turbine by employing a combined Bach-type and H-Darrieus rotor system	Energy Conversion and Management	Vertical axis wind turbine; CFD; Hybrid rotor; Sustainable design; Operational range; Startup torque	76	2019	Simulation and modeling proposal for efficiency and range improvement aiming at energy sustainability perspectives.
(Ahlgren Ode & Lagerstedt Wadin, 2019)	Business model translation-The case of spreading a business model for solar energy	Renewable Energy	Solar photovoltaics; Business model; Translation; Renewable energy; Entrepreneurs hip	36	2019	Explores how a startup in the Netherlands established the third-party ownership business model in the Dutch energy market.
(Maximilian Palmié et al., 2021)	Startups versus incumbents in 'green' industry transformations: A comparative study of business model archetypes in the electrical power sector.	Industrial Marketing Management	Business model Electricity sector Industry transformation Sustainability Comparative research Disruption	30	2021	This paper performs a comparative analysis of startups and incumbents based on the archetypes of empirically distilled business models and develops propositions about startups, incumbents, and business models in industry transformations.
(Greer et al., 2020)	The diffusion of circular services: Transforming the Dutch catering sector	Journal of Cleaner Production	Food-energy-water nexus; Circular economy; Urban living lab; Transitions; Diffusion pathways; Niche-regime interaction	27	2020	Offers new empirical insights on how to scale up and scale out clean production practices circular economy through circular startups, summarized in 15 observed principles for integrating innovations.
(Amany El-Zonkoly, 2015)	Application of smart grid specifications to overcome excessive load shedding in Alexandria, Egypt	Electric Power Systems Research	Demand side management programs; Energy resources schedule; Unit commitment planning; MFA optimization	18	2015	Proposal of a modified algorithm to minimize the operational cost.
(Sajjad Haider, Shahmoradi-Mogh adam,	Algorithm and Optimization Model for Energy Storage Using	IEEE Access	Energy storage system; gravity;	8	2020	This article focuses on the possibility of energy storage in vertically stacked blocks.

International Journal of Knowledge Engineering and Management,
Florianópolis, v. 12, n. 32, p. 24-68, 2023.
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Schonberger, & Schegner, 2020)	Vertically Stacked Blocks		mathematical modeling; optimization; sustainability			
(Ranbhise, 2014)	Green computing a way towards environmentally sustainable future	2014 International Conference on Contemporary Computing and Informatics (IC3I)	-	8	2014	This article deals with green computing, defines problems in different areas, and presents approaches. Presents a model for implementing green strategies in small businesses.
(Ginsberg & Marcus, 2018)	Venture capital's role in creating a more sustainable society: The role of exits in clean energy's investment growth	Sustainability, Stakeholder Governance, and Corporate Social Responsibility	Venture capital; Clean Energy; Sustainability; Performance expectations; Risk; Return	7	2018	This chapter explores the constraints that the financial obligations that VCs (venture capitalists) have to their main funders place on their role in creating a more sustainable global society.
(Juha & Kari, 2017)	Development Trajectory of An Innovation-Based Environmental Technology Start-Up	International journal of innovation and economic development	Environment, Entrepreneurship, Sustainability, Innovation, Growth, Start-up	6	2017	This research paper focuses on the growth models of new commercial enterprises and their applicability to a specific type of start-up, growth company based on environmental technology through a case study.
(de Sousa et al., 2016)	Innovation Systems of Ethanol in Brazil and the United States: Making a New Fuel Competitive	Evolution, Risks, and Uncertainties	Innovation systems; second-generation ethanol; energy policy coordination; biofuels regulation; sustainability	4	2016	This chapter juxtaposes the innovation systems for ethanol in Brazil and the United States, the world's two largest producers, assessing their main strengths and weaknesses. Emphasis is placed on coordinating energy policy with industrial and agricultural policies, environmental aspects, and regulations.
(Ahmed, Okumura, & Arai, 2016)	Identifying Green Services using GSLA Model for Achieving Sustainability in Industries	International Journal of Advanced Computer Science and Applications	GSLA; Green Services; GaaS; Sustainability; Informational model	3	2016	This research looks to project all the missing green services for sustainability using the Green SLA global information model.

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(Artie Ng, Adam Wong, & Tai-Ming Wut, 2016)	Second-movers' advantage of utilizing Big Data to enhance sustainability performance: the case of elevator industry	International Conference on Industrial Engineering and Operations Management	big data; second-movers' advantage; sustainability; elevator industry	2	2016	This article presents a conceptual framework for the advantages of the second movement in light of entrepreneurial opportunities with big data analytics. Also, exploring the sustainability performance that can be improved with big data analysis for the case of elevator operators serving skyscrapers.
(de Mergelina & Lemus-Aguilar, 2021)	Current Innovation Sources Driving the Spanish Electric Power Sector	Ingeniería e Investigación	Innovation; electric power; Spain; innovation sources	2	2021	These authors concluded that there are currently nine sources of innovation that are redesigning the industry: renewable energy, energy storage systems, electric vehicles, Industry 4.0, smart grids, blockchain, distributed and self-consumption generation, smart client, and demand response.
(Ye, Mohamadian, & Ye, 2006)	Process Control Potentials on Gasification and Combined Cycle Integration	2006 IEEE International Conference on Computational Cybernetics	Gasification; Combined Cycle; Fuzzy Control; PID Control; Genetic Algorithms	1	2006	This article presents some practical control approaches for individual components of ICCC plants are explored.

Source: Prepared by the authors (2021).

To highlight the authors most cited by the selected papers, a co-citation analysis was carried out, i.e., one looks for which authors are most cited in the energy market. Figure 2 shows the co-citation map, where it can be seen the presence of two clusters highlighted in red and green. For this analysis authors with 3 or more citations were considered.

Figure 2 - Co-citation map of the most cited authors.

International Journal of Knowledge Engineering and Management,
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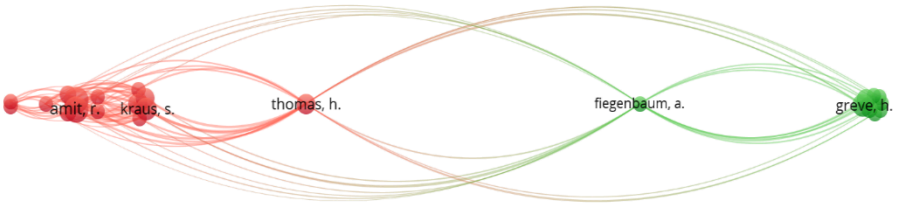

Source: Prepared by the authors (2021).

By investigating the author co-citation map we can infer that there are few authors with 3 or more citations, evidencing that this theme is still little explored in the literature, with the authors "Amit,r" and "Greve,h" being the most cited with 8 and 6 citations, respectively. A third analysis was then performed, checking the plus and author keywords. In Figure 3 we illustrate the plus keywords, which are words that usually appear in the titles of a paper's reference and not necessarily in the title of the papers or as author keywords (J. Zhang et al., 2016).

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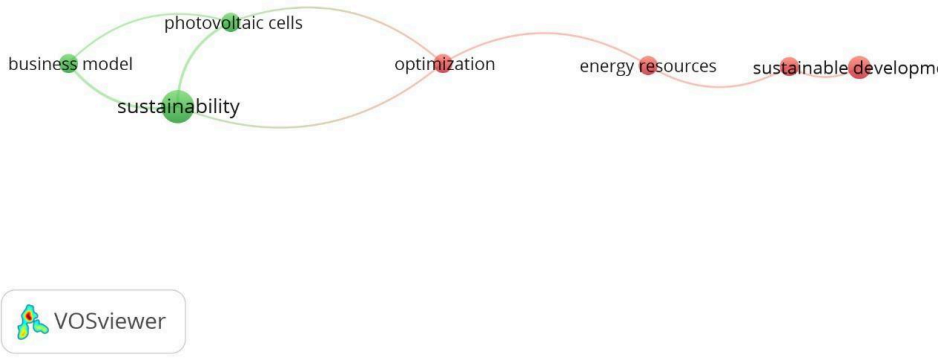
Figure 3 - Keywords plus.



Source: Prepared by the authors (2021).

The most used word is 'sustainability' and in the same cluster are the words 'photovoltaic cells' and 'business model'. In the second cluster are the words 'optimization', followed by 'energy resources' and 'sustainable development'. The term sustainability, which is highlighted in the keywords plus, is broad and is related to the aspects of environmental conservation, social equality, and economic security (Munaro, Freitas, Tavares, & Bragança, 2021). The energy sector is going through transformations regarding sustainability and energy transition, and all this affects business models, which justifies keywords focused on the business model and renewable energy resources. One example is the high energy consumption associated with street lighting, this is already in the business model offered in most European cities, to provide light throughout the night to ensure visibility (Pardo-Bosch,

International Journal of Knowledge Engineering and Management,
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Blanco, Sesé, Ezcurra, & Pujadas, 2022). Smart street lighting integrates sensors and controls through information and communication technologies to improve system efficiency and reduce energy consumption (Castro, Jara, & Skarmeta, 2013; Sutopo, Mardikaningsih, Zakaria, & Ali, 2020).

More sustainable power generation is therefore a priority on many policy agendas (Maximilian Palmié et al., 2021), Hockerts and Wüstenhagen (2010) (Hockerts & Wüstenhagen, 2010) presented the differential that startups and incumbents play in transforming sectors towards sustainability. They argue that startups are more likely to develop into sustainable entrepreneurship than incumbents, thus creating an imbalance in the market. Business models, a keyword that appears in the same cluster as sustainability, play an important role in driving sustainable transitions (Sarasini & Linder, 2018). For example, a business model can collaborate with the diffusion of sustainable energy technologies in developing countries and consequently facilitate the adoption of electric vehicle technology (Jolly, Raven, & Romijn, 2012; Weiller, Shang, Neely, & Shi, 2015). Geissdoerfer et al. (2018) (Geissdoerfer, Vladimirova, & Evans, 2018) state that one approach to gaining a competitive advantage and improving sustainability is the use of innovative business models. Elmustapha and Hoppe (2020) (Elmustapha & Hoppe, 2020) believe that to achieve sustainable development, a shift to innovative business models for renewable energy can bring an outcome with a strong relationship between business and society. Figure 4, presents the authors' keywords that bring a list of terms that present the main evidence from the publications (Li, Ding, Feng, Wang, & Ho, 2009).

International Journal of Knowledge Engineering and Management,
Florianópolis, v. 12, n. 32, p. 24-68, 2023.
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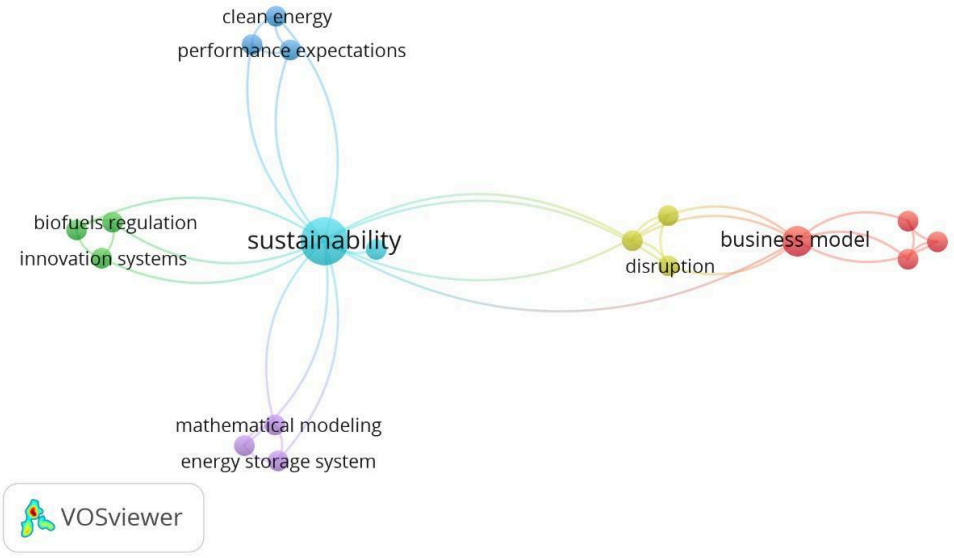
Figure 4 - Authors Keywords.



Source: Prepared by the authors (2021).

When analyzing the keywords of the authors, the term 'sustainability' was again highlighted, as well as the term 'business model'. We also verified the presence of the term 'innovation systems'. And again, terms linked to the issues of energy resources such as 'clean energy', 'energy storage system', and 'biofuels regulation'. Reinforcing that a business model can collaborate with the diffusion of sustainable energy technologies and that sustainability is related to energy resources, in this case, and in the keywords plus, we can say that related to energy resources by clean source.

The fourth analysis is related to the countries referring to the publications. In this analysis we have evidenced by Figure 5 the presence of two clusters, the first highlighted in red and the second highlighted in green, bringing in it the relationship established between the

International Journal of Knowledge Engineering and Management,
Florianópolis, v. 12, n. 32, p. 24-68, 2023.
• ISSN 2316-6517 •
• DOI: 1029327 •

countries. Cluster 1 is formed by Brazil, China, Russia, and the United States, and cluster 2 is formed by Finland, Sweden, and Switzerland.

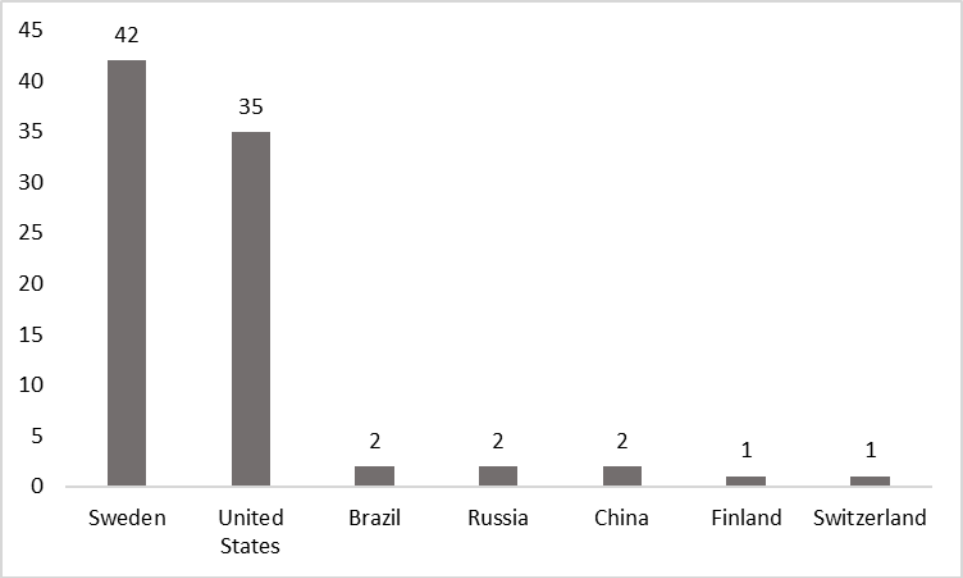
Figure 5 - Analysis of publications by countries and their relationships.

Source: Prepared by the authors (2021).

Cluster 2 is referenced as the leader as Sweden has 42 citations. Figure 6 presents the citation data by country, where the United States comes second with 35 citations.

International Journal of Knowledge Engineering and Management,
Florianópolis, v. 12, n. 32, p. 24-68, 2023.
• ISSN 2316-6517 •
• DOI: 1029327 •

Figure 6 - Number of publications per country extracted by VOSviewer data.

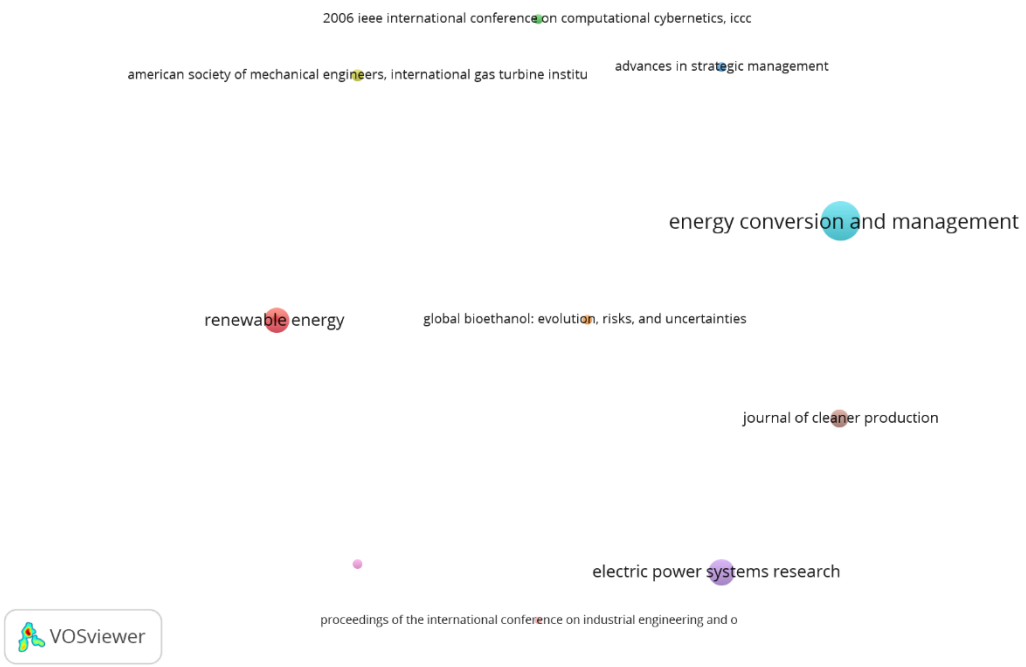


Source: Prepared by the authors (2021).

To highlight the sources with the largest number of publications about energy markets and energy startups, the analysis of citations per source was performed, i.e., we sought to explore which are the main sources found in the selected documents. Figure 7 shows that the relationships among the sources with publications on the theme are quite scarce (11 organizations in a total of 14 papers).

International Journal of Knowledge Engineering and Management,
Florianópolis, v. 12, n. 32, p. 24-68, 2023.
• ISSN 2316-6517 •
• DOI: 1029327 •

Figure 7 - Mapping of the main sources of the selected papers.



Source: Prepared by the authors (2021).

By analyzing the size of the circles evidenced in Figure 7, we can infer that the source "Energy Conversion and Management" is the most cited source, followed by "Electric Power Systems Research", "Renewable Energy" and "Journal of Cleaner Production". Table 4 presents the number of citations for each source from the mapping performed by VOSviewer.

Table 4 - Number of citations by source

Source	Nº Citations

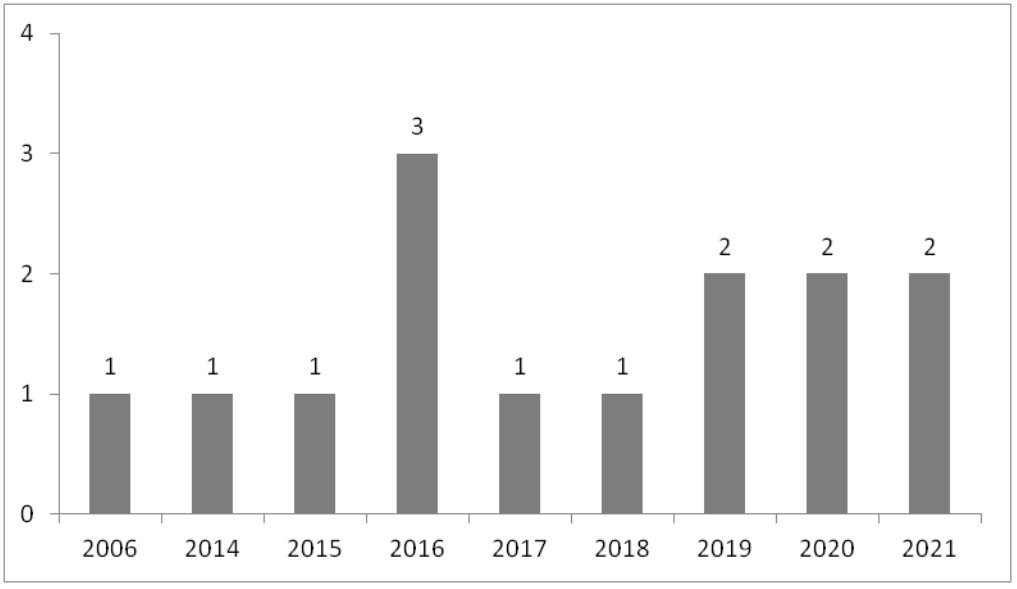
International Journal of Knowledge Engineering and Management,
Florianópolis, v. 12, n. 32, p. 24-68, 2023.
• ISSN 2316-6517 •
• DOI: 1029327 •

Energy Conversion and Management	29
Electric Power Systems Research	13
Renewable Energy	12
Journal of Cleaner Production	6

Source: Prepared by the authors (2021).

The source Energy Conversion and Management, presented 29 citations, standing out among the other sources. When we also analyze the year of publication of the papers, we have the following results evidenced in Figure 8.

Figure 8 - Total publications per year of the selected papers.



Source: Prepared by the authors (2021).

Figure 8 shows us the scarcity of papers related to the theme startups-energy market-sustainability, where in the last 3 years we had only 6 publications. Following the

International Journal of Knowledge Engineering and Management,
Florianópolis, v. 12, n. 32, p. 24-68, 2023.
• ISSN 2316-6517 •
• DOI: 1029327 •

research, a study of the 14 selected documents was conducted and is presented in the next section.

4.2 Perspectives of the energy sector in the diffusion of sustainability

After the complete reading of the 14 selected papers, it was possible to obtain the trends, and understand what the perspectives of the energy market in the diffusion of sustainability. Table 5 presents the trends and the respective authors.

Table 5 - Characterization of the trend in relation to the energy market diffusion for sustainability.

Author	Trend
(S Haider, Shahmoradi-Moghadam, Schonberger, & Schegner, 2020)	Energy storage in vertically stacked blocks
(de Sousa et al., 2016)	Flexibility of the fuel matrix
(Juha & Kari, 2017)	Eco-entrepreneurship
(Ahmed et al., 2016; Ranbhise, 2014)	Green computing
(Hosseini & Goudarzi, 2019; Ye et al., 2006)	Sustainable green engineering
(Ginsberg & Marcus, 2018)	Venture capital in clean energy technologies
(M Palmié et al., 2021)	Disruptive transformation of business models
(A El-Zonkoly, 2015)	Management of energy demands and resources
(Greer et al., 2020)	Circular economy and clean production
(Ahlgren Ode & Lagerstedt Wadin, 2019)	Third-Party Owned Business Model
(Ng, Wong, & Wut, 2016)	Disruptive Innovation

International Journal of Knowledge Engineering and Management,
Florianópolis, v. 12, n. 32, p. 24-68, 2023.
• ISSN 2316-6517 •
• DOI: 1029327 •

(de Mergelina & Lemus-Aguilar, 2021)	Open Innovation

Source: Prepared by the authors (2021).

Once the trends have been identified, it is possible to describe the view that each author brought regarding their study. About Vertically Stacked Block Energy Storage, is a long-term gravity energy storage system and is developed by commercial companies (Sajjad Haider et al., 2020). The gap that exists between energy supply and consumption can be mitigated by storing excess energy, Haider Et al. (2020) (Sajjad Haider et al., 2020) believe that using a set of DC motors to store blocks weighted on top of each other is a solution. Hydrogen is an example of a long-term storage technique where excess energy is used to produce hydrogen in an electrolyzer, which can then be used in a fuel cell later (Pazouki, Haghifam, & Olamaei, 2013).

Another trend identified is the Flexibilization of the Fuel Matrix. Given the importance of energy security for economic development, one trend in energy policy is the flexibilization of the fuel matrix with an increasing diversification of biofuels, which in some ways reduces fossil fuels and reduces energy vulnerability (de Sousa et al., 2016). This flexibilization involves the inclusion of alternative energy sources and this can circumvent the depletion of fossil resources, as well as assist in reducing the effects caused by conventional energy consumption such as global warming.

According to Juha and Kari (2017) (Juha & Kari, 2017), a startup is a company that has new solutions and the desire for opportunities to grow in many dimensions, with the high risk involved. In this sense, the authors address Eco-entrepreneurship, as being an activity that in case of successful implementation can result in a positive effect on the environment and

International Journal of Knowledge Engineering and Management,
Florianópolis, v. 12, n. 32, p. 24-68, 2023.
• ISSN 2316-6517 •
• DOI: 1029327 •

sustainability. They found that clean technology solutions are needed, focused on the need for waste treatment and green energy solutions.

Green Computing is another term presented as a trend. According to Ranbhise (2014) (Ranbhise, 2014), three areas can significantly impact an organization's carbon footprint: organization structure and functions; data centers; technology. The author believes that corporate data centers can account for up to half of a company's energy bill and approximately half of the carbon emitted. Ahmed et al., (2016) (Ahmed et al., 2016) point out that Green Computing can contribute to reducing energy consumption to increase environmental awareness as a means of protecting and restoring natural ecosystems. With this idea, other authors address that technology companies or service providers need to think about the business scope with a green and sustainable perspective (Andreopoulou, 2013).

In the same synchronicity as Green Computing, another trend is Sustainable Green Engineering. According to Ye et al. (2006) (Ye et al., 2006), Sustainable Green Engineering requires sustainable products to be recyclable, renewable, non-hazardous, non-toxic, and energy efficient. For Hosseini (2019) (Hosseini & Goudarzi, 2019) we also highlighted the Green Sustainable Engineering trend, which was addressed through a simulation and modeling proposal for efficiency improvement aimed at energy sustainability, where the Green Engineering model values processes that do not have unnecessary waste and that help conserve natural resources, such as those with higher energy efficiency.

Following the identified trends, Venture Capital in Clean Energy Technologies can be a pioneer in generating a sustainable society (Ginsberg & Marcus, 2018). The authors state that sustainability achievements depend on stakeholder relationships. Venture capitalists can make investments that further the cause of sustainability, however, these investments require some type of above-average economic return for those who entrust their money to venture

International Journal of Knowledge Engineering and Management,
Florianópolis, v. 12, n. 32, p. 24-68, 2023.
• ISSN 2316-6517 •
• DOI: 1029327 •

capitalists. Ginsberg and Marcus (2018) (Ginsberg & Marcus, 2018) reveal that this expected nature pays off when venture capitalists invest in cleaner energy startups.

In the work developed by Palmié et al (2021) (Maximilian Palmié et al., 2021), we have the approach to the disruptive transformation of business models that are towards sustainability that appear as a market perspective for sustainability diffusion, as business models have become the main way of characterizing companies, where the process of disruption is something complex and challenging since the risks are many and business success may take time to come.

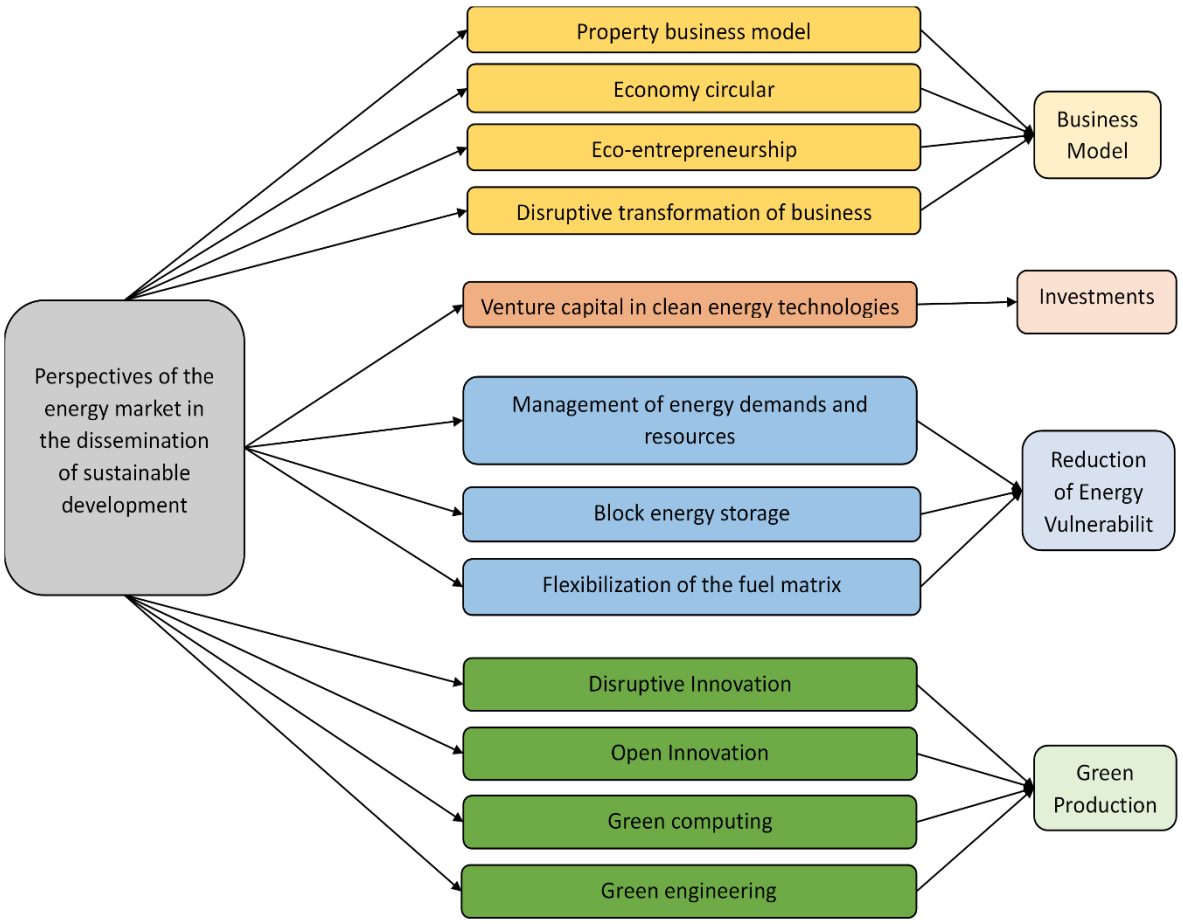
As evidenced in the work of (Amany El-Zonkoly, 2015), one has the trend of managing energy demands and resources, which is suggested by the proposition of a modified algorithm to minimize the operational cost. Greer (2020) (Greer et al., 2020) presents empirical insights on how to scale up and scale clean production practices for a circular economy through circular startups, highlighting the circular economy as a diffuser for sustainability. Ahlgren (2019) (Ahlgren Ode & Lagerstedt Wadin, 2019) addresses the trend of third-party ownership business models in the energy market, which is based on offering services related to PV generation rather than selling the product.

In the papers by Artie W. Ng (2016) (Artie Ng et al., 2016), the disruptive innovation perspective is highlighted to improve the operational performance to meet the demand without having to consume more resources or increase its structure in the same proportion (incremental growth of the company), and Mergelin (2021) (de Mergelina & Lemus-Aguilar, 2021) addresses about the open innovation perspective by searching for the types of technologies that will enable energy companies to redesign the power sector.

Figure 9 presents the 12 trends found in the selected papers regarding energy market diffusion for sustainability.

International Journal of Knowledge Engineering and Management,
Florianópolis, v. 12, n. 32, p. 24-68, 2023.
• ISSN 2316-6517 •
• DOI: 1029327 •

Figure 9 - Energy market diffusion trends and relationships for sustainability.



Source: Prepared by the authors (2021).

International Journal of Knowledge Engineering and Management,
Florianópolis, v. 12, n. 32, p. 24-68, 2023.
• ISSN 2316-6517 •
• DOI: 1029327 •

After the analysis of the trends, we can identify 4 perspectives coming from: Business Model, Green Production, Reduction of Energy Vulnerability, and Investments. These perspectives point to the sustainable growth of the market because they bring attitudes that aim to maintain the management in an efficient way for economic development through the search for investments and new business models, green production without waste using the resources in an intelligent way to decrease its vulnerability. The business model of energy startups enters as a strong alternative to firm this propensity. This can be an important opportunity to reorganize the energy system on more solid and sustainable bases: efficiency, greater participation of renewable sources, and decentralization of energy production.

The reduction of energy vulnerability is related to sustainability, as there is a search for more efficient management related to energy resources and the fuel matrix. According to Almeida Collaço and Bergmann (2017) (de Almeida Collaço & Bergmann, 2017), the development of energy planning at the local level, based on the use of different energy sources as a tool to achieve sustainability contributes to the integration of renewable energy production along with the search for energy efficiency in a clean way. The management of energy demand and resources, as well as energy storage, is necessary to reduce energy vulnerability. Electricity shortages or power shortages can be caused by different factors, which include insufficient and/or compromised power generation, transmission, or distribution inputs. Some industries have shifted their operations to evenings and weekends when electricity demand is lower, this helps reduce demand during the peak, however, it does not decrease electrical consumption (Balachander & Amudha, 2018).

In addition to variables related to high consumption, the consequences of climate change and global warming put pressure on nations in seeking to implement strategic methods to increase the sustainability of the environment to protect natural resources (Alyami, Rezgui, & Kwan, 2013). Regarding the flexibilization of the fuel matrix, Duarte Castro et al. (2021)

International Journal of Knowledge Engineering and Management,
Florianópolis, v. 12, n. 32, p. 24-68, 2023.
• ISSN 2316-6517 •
• DOI: 1029327 •

(Duarte Castro, Cutaia, & Vaccari, 2021) states that the electric vehicle fleet has been increasing worldwide due to the need to build a low-carbon economy. In addition, the high share of renewable energy in the matrix can act as an incentive for the adoption of renewable energy storage.

Regarding the business model perspective, it is possible to identify that the trends that are part of this perspective relate to a business model focused on eco-entrepreneurship and a circular economy, which consequently entails a disruptive transformation in traditional business models to prioritize sustainable issues. With the growing awareness of society about the environment, pressures from the government, institutions, and consumers have instigated companies' search for better environmental performance and this search starts with the selection of green suppliers (Gao et al., 2021) . In addition to the identification of green suppliers, there is the introduction of eco-labels to facilitate the choice of products and thus inform consumers about which products are less harmful to the environment and respect social and economic issues to promote responsible consumption. In this way, it is possible to show the transparency of eco-enterprises and companies that make this commitment. Information, such as consumption-based carbon accounting in a store can provoke behavioral change (Calderon-Monge, Redondo-Rodriguez, & Ramírez-Hurtado, 2021).

This transition to a green economy enables economic growth and investment as it increases environmental quality and social inclusion (Jayasinghe, Liyanage, & Baillie, 2021). A sustainable and innovative business model focused on the green economy process is an important strategy for realizing ecological and economic value (Lu et al., 2022). Many companies are migrating from conventional linear consumption to the circularity business model due to customer demand and the high operating cost of virgin raw materials (Khan, Shah, Yu, & Tanveer, 2022). In contrast to the linear economy of the traditional system, the

International Journal of Knowledge Engineering and Management,
Florianópolis, v. 12, n. 32, p. 24-68, 2023.
• ISSN 2316-6517 •
• DOI: 1029327 •

circular economy features the reuse, remanufacturing, or recycling of used product components and materials to produce new ones (Honic, Kovacic, Aschenbrenner, & Ragossnig, 2021). This reduces the consumption of scarce virgin raw materials and natural resources as old components of used products are reused; thus, the combined effect of lower consumption and less waste reduces environmental degradation (Upadhyay, Laing, Kumar, & Dora, 2021).

From the perspective of green production, the related trends show that it is necessary to stimulate the driving force of innovation to transform production from engineering and technology to cleaner production. As the green production process grows, it is also possible to develop other segments, since society's dependence increases and it becomes essential to expand the capacity for renewable energy. Innovation models present themselves as a great tool to seek the rise of green production, as proposed by Hosseini and Goudarzi (2019) (Hosseini & Goudarzi, 2019) who presented in their work an innovative hybrid turbine project bringing green engineering as a foundation for sustainability and Ranbhise (2014) (Ranbhise, 2014) who suggests the use of green data centers focused on management for energy savings and reduced environmental impact during the use of electricity for example. Considering that the trend in the energy sector is towards decentralization and digitalization through new technologies and smart services, there is an urgency for the energy sector to awaken to its potential, whether through innovation, engineering, and technology.

For the last perspective defined, investments, it is believed that through venture capital it is possible to bring about the innovation and technology needed to achieve sustainability in energy systems. Venture capital - a type of investment that bets on firms with high growth potential - can help energy startups enter existing sectors or create market niches. This type of investment is characterized by the purchase of equity aimed at increasing the value of the shares for later exit from the operation (Gaddy, Sivaram, Jones, & Wayman, 2017).

International Journal of Knowledge Engineering and Management,
Florianópolis, v. 12, n. 32, p. 24-68, 2023.
• ISSN 2316-6517 •
• DOI: 1029327 •

Early-stage venture capital investment is also an important component for the development of new technologies because it is in the early stage that a startup, for example, can fill the gap between research and development since they have a business model related to providing solutions, even if the return is in the long term.

In addition to a longer payback time, there may be barriers because energy startups are inserted in a regulated environment (Mendonça, 2018). Despite these barriers, the trend towards investments in renewable production should be motivated by environmental and economic factors, in its growth potential, and not just based on profit. Another way for clean energy startups to succeed is to seek a broader view of the set of funding sources than just venture capital and to wait longer before raising venture capital money. In the interim, they can reduce capital expenditures by using shared or leased resources at universities, research institutes, or incubators. They can leverage federal and state grants to advance technology development before raising substantial funds and start counting down to investor return expectations (Gaddy et al., 2017).

After analyzing the trends, we identified four main perspectives: business models, green production, reduction of energy vulnerability, and investments. These perspectives indicate a pathway for sustainable market growth, as they promote actions aimed at efficient management for economic development, driving the pursuit of investments and new business models. Green production is highlighted as a strategy that minimizes waste and utilizes resources intelligently, contributing to the reduction of energy vulnerability. In this context, the business model of energy startups emerges as a promising alternative to consolidate this trend. This represents a significant opportunity to reorganize the energy system on more solid and sustainable foundations, focusing on efficiency, a greater share of renewable sources, and the decentralization of energy production. These changes not only

International Journal of Knowledge Engineering and Management,
Florianópolis, v. 12, n. 32, p. 24-68, 2023.
• ISSN 2316-6517 •
• DOI: 1029327 •

reinforce the sector's resilience but also create a more favorable environment for innovation and competitiveness in the energy market.

5. Conclusion

In these papers, the objective was to identify through a bibliographic mapping what is the scenario of startups in the energy market and what are the market perspectives in the dissemination of sustainable development. To achieve this objective, a systematic mapping of the literature was carried out, where the VOSviewer software was used to construct the analyses and to read the documents thoroughly to understand the perspectives.

Regarding the theoretical contributions of this paper, it can be observed that the results show a scarcity of publications related to the topic involving energy startups, the energy market, and sustainability. When investigating the publications, Sweden is the country that publishes the most on the subject, followed by the United States. And the most cited documents present a proposal for simulation and modeling to improve energy efficiency.

When analyzing the sources of publication, Energy Conversion and Management has been the most productive journal in publishing research related to the theme. Based on the analysis of keywords used in the publications, the term 'sustainability' is highlighted, in addition to terms such as 'business model' and words related to innovation such as 'innovation systems' and issues related to energy resources such as 'clean energy'.

By understanding the perspectives of the energy sector for the diffusion of sustainability, we identified 12 trends, which are not only theoretical contributions of this paper but also practical contributions to the diffusion of the sector in what involves startup and sustainability. These trends correspond to 4 perspectives such as business model, green production, decreasing energy vulnerability, and investments. It is possible to identify sustainable growth in the sector since the perspectives converge towards more efficient management in

International Journal of Knowledge Engineering and Management,
Florianópolis, v. 12, n. 32, p. 24-68, 2023.
• ISSN 2316-6517 •
• DOI: 1029327 •

economic development and the trends help in the identification of improvements in business models and the development of more sustainable projects since they can be applied in any area that aims at a more sustainable operation.

The topic of startups in the energy market presents a gap in the academic literature, particularly regarding the role of these companies as catalysts for sustainable innovations and drivers of change in the sector. Mapping existing initiatives and analyzing trends highlight a lack of studies that deeply explore the sustainability drivers that can be leveraged as strategic tools for the growth of energy startups and to increase their competitiveness. In this context, future research can focus on identifying sustainable practices and business models that maximize positive impacts in the energy sector, thereby strengthening the market positioning of these companies and generating both economic and environmental value. Thus, it is possible to contribute to a body of literature that provides practical and theoretical guidance for the development of new startups, promoting a more sustainable and innovative ecosystem.

Emerging trends, such as efficient resource management, the adoption of renewable energy, and the creation of socio-environmental value, can significantly increase the competitiveness of the energy market by redefining business standards and driving innovation. Efficient resource management, for example, allows for operational cost reductions and optimizes the use of inputs, which boosts productivity and improves profit margins. The adoption of renewable energy, in turn, not only complies with increasingly stringent regulatory requirements but also positions companies as leaders in a market that values sustainable practices, attracting investments and strategic partnerships. Meanwhile, creating socio-environmental value strengthens corporate reputation and enhances stakeholder engagement, which is essential in a highly competitive sector. By incorporating these sustainability drivers, companies in the energy sector can align economic growth with

International Journal of Knowledge Engineering and Management,
Florianópolis, v. 12, n. 32, p. 24-68, 2023.
• ISSN 2316-6517 •
• DOI: 1029327 •

environmental responsibility, providing a robust and sustainable competitive advantage in the long term.

It is suggested as future work to carry out a subsequent analysis of the business model of energy startups as a guide for sustainable growth in the energy sector since in this work a mapping and interpretation of the panorama was carried out, and it is necessary to draw a subsequent cause and effect relationship. It is also worth studying the sector's innovation and sustainability practices, as the focus on sustainable solutions is worldwide and, while other sectors suffer from a lack of capital, the energy sector has managed to raise contributions without losing sight of the notion that the green economy and more recent than the concept of sustainable development, and its premise is efficiency in resource use, low carbon emissions, and social inclusion. These topics as a proposed sequence of work demonstrate the importance of this initial study that will serve as a basis for the next steps.

International Journal of Knowledge Engineering and Management,
Florianópolis, v. 12, n. 32, p. 24-68, 2023.
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