energies

MDPI

Review

A Comprehensive Review of Research Approaches in the Energy Sector: A Management Sciences Perspective

Marek Szarucki [1], Radosław Rybkowski [2], Justyna Bugaj [3] and Klaudia Bracio [1,*]

[1] Department of Strategic Analysis, Institute of Management, College of Management and Quality Sciences, Cracow University of Economics, 27 Rakowicka St., 31-510 Krakow, Poland
[2] Jagiellonian University, 24 Golebia St., 31-007 Krakow, Poland
[3] WSB University, 1C Z. Cieplaka St., 41-300 Dabrowa Gornicza, Poland
* Correspondence: klaudiabracio@gmail.com

Abstract: The energy sector plays a crucial role in addressing the global challenges of achieving sustainability by using renewable energy sources as well as by increasing energy efficiency and conservation while gaining energy security and safety. Choosing an appropriate research method to investigate the energy sector's management has become more complex, involving multiple factors such as technical, environmental, social, political and economic. Additionally, considering the important role of energy in modern society, it is imperative to study the current methods used in examining the energy sector and to create an appropriate theory of the managing energy sector enterprises in the future. The main purpose of this review paper is to explore which research methods and approaches are utilized by researchers studying the issues of the managing energy sector enterprises. This article presents a systematic review based on a qualitative synthesis of the accessible publications from the Scopus database. In this review, which also adhered to strict search and filter criteria, a total of 77 articles were selected and synthesized. The selected papers met the inclusion criteria and a bibliometric visualization approach was applied using MAXQDA2020 software. The present paper reveals existing research trends in utilizing various research approaches in the energy sector from the perspective of management sciences in the last ten years and also provides future research avenues in the discussed area of knowledge.

Keywords: research methods; research approaches; energy sector; literature review; management sciences

Citation: Szarucki, M.; Rybkowski, R.; Bugaj, J.; Bracio, K. A Comprehensive Review of Research Approaches in the Energy Sector: A Management Sciences Perspective. *Energies* **2022**, *15*, 8495. https://doi.org/10.3390/en15228495

Academic Editor: Krushna Mahapatra

Received: 2 October 2022
Accepted: 8 November 2022
Published: 14 November 2022

1. Introduction

Changes in the organization of the energy sector related to the activities from mining to end-use energy, environmental problems, the tendency to liberalize energy markets, socio-economic problems within the context of sustainable development, as well as those involving the separation of previously integrated activities, create new challenges as well as new opportunities for both managers and policy makers. Moreover, the energy sector involves various actors (energy service companies from numerous industries, media, customers, governments, system and market operators, regulatory agencies, as well as a wide range of issues of different natures (policy design, market modeling, technical and operational, systems management, short-term and long-term planning, etc.) [1,2]. All these mentioned issues raise a vivid interest among researchers of the management sciences' discipline and need the utilization of appropriate research methodologies.

The energy sector enterprises basically deal with energy production and selling. The detailed functions include, among others, the production, extraction, refining and distribution of fuels. There is a high level of differentiation of enterprises in the energy sector, among which companies can be characterized, on the one hand, as more traditional (oil and gas, coal) and, on the other hand, as more innovative (nuclear, solar, thermal, hydro or wind energy). One can also distinguish the presence of stakeholders of energy companies,

whose requirements very often contradict the actions taken by companies in a given sector. The energy sector is an extremely important sector for every economy due to the impact it has on the functioning of society and on public and private infrastructures, which implies an increase in the number of companies operating in a given sector. [3]. The efficient functioning of energy enterprises depends on dealing with various circumstances as well as challenges faced by the management bodies. Managers often have to deal with problems not only in the operational sphere but also in the strategic sphere. Enterprises operating in the energy sector focus on managing, among others, innovation and finance. Moreover, an important aspect for these companies is marketing, as well as organizational restructuring and strategic management. [4]. In these tempestuous times, it is extremely important, but at the same time complicated and very difficult, to create a business management theory corresponding to the specifics of the energy sector.

The progressive liberalization of the legal regulations in the energy sector, in principle aimed at increasing the competitiveness of enterprises operating in a given environment, may lead to the improvement of the position of some players in relation to others through their market power. However, the research focus on management issues in the energy sector is still under-represented. In order to take into account the potential of market power as well as the uncertainty of large companies about the future, some researchers use quantitative methods that include elements of stochastic and game theory. The high level of complexity of the results obtained with the use of the models in question is influenced by the possibility for players to use both strategic and protective measures. Other researchers use qualitative methods due to their nature, allowing the data obtained from respondents to be monitored and then processed to obtain attractive and ambiguous results [5].

To our best knowledge, in the scientific literature there is a lack of a thorough conceptual framework for the selection of appropriate research methods to study problems in energy companies. We act in response to the identified research gap by performing a systematic literature review of scholarly journal publications in the Scopus database in the field of energy sector enterprises and use its outcomes to build a comprehensive research approach in the energy sector. In this perspective, we link metrics by demonstrating how emerging scientific articles in the energy sector not only offer complementarity to existing articles using quantitative and qualitative methods but also shed light on the underlying structure. It should be emphasized that, in the current literature on the subject, there is no scientific publication that includes a literature review on the issues discussed above. Therefore, this article, which is a response to the mentioned research gap, is important for the advancement of the management sciences through the consolidation of knowledge.

Our paper is also an answer to the call formulated by Parisa Maroufkhani, Kevin C. Desouza, Robert K. Perrons and Mohammad Iranmanesh in their article: "Digital transformation in the resource and energy sectors: A systematic review": "to conduct a systematic literature review using other keywords to be able to identify more studies on the topic" [6]. Additionally, there is a need for estimating which methods are used most frequently and most efficiently in the energy sector [7]. With this paper, we try to respond to these two research gaps.

The main purpose of this review paper is to explore which research methods and approaches are utilized by researchers studying issues of managing energy sector enterprises. With reference to the research gap in the literature and the research goal of this article, we conducted a systematic review of the literature, studying 77 articles from the Scopus database on the topic of research approaches in the energy sector. The database was selected due to its breadth and availability. The selection of publications was made using keywords described in more detail in Section 3. It should be emphasized that, due to the general availability of the Scopus database as well as the unambiguous criteria for the selection of publications, the database we have created can be replicated; moreover, it may be extended by newer publications in the future.

This article is an overview of the scientific literature research on approaches to management issues in the energy sector by assessing and selecting the appropriate methods for

investigating the problems in this sector. In particular, we aim to examine the published articles in terms of the methods described therein from the management science perspective in relation to the energy sector to determine which methods are used to study the energy sector (quantitative or qualitative) and how these reviews bring value to this sector.

This article identifies the current research gaps and can serve as a map of the work conducted so far in the energy sector and the available data in this area. The researched publications are classified according to their type, their achieved result and their applied methods. The article presents a holistic view of publications regarding a given sector, thus enabling practitioners and scientists to identify research approaches to energy sector management while taking into account its complexity. The information from this article allows the methods used to be tested in terms of their effectiveness and frequency of use, while future researchers can find new research gaps that could become the subject of their research.

Our paper is organized as follows. The second section provides the theoretical background of the study. Section 3 defines the research methodology. In Section 4 we show the results and themes and we identify patterns that become visible in the literature and offer recommendations on where potential research should concentrate in this area. In Section 5 we conclude with a brief synthesis and summary of the key matters.

2. Theoretical Background

Over the past twenty years, industrial companies have started to look at the energy sector through its management as an essential support for their activities. This is due, inter alia, to the increase in energy costs, which constitute an escalating part of production costs. Currently, energy costs are not treated as overheads (as was the case a few years ago), but are considered a separate category that requires efficient management [8]. This situation has changed with the considerable rising energy-sourcing prices in Europe within the last decade, exemplified by the development of electricity prices for industrial consumers. According to the OECD report: "Consumer prices in the OECD area rose by 8.8% year-on-year in March 2022, compared with 7.8% in February 2022, and just 2.4% in March 2021; it was their sharpest increase since October 1988. Around one fifth of OECD countries recorded double-digit inflation, with the highest rate was in Turkey at 61.1%" [9]. Consequently, the number of papers addressing energy-related problems has grown in recent years and expanding activity regarding the managing energy sector can be revealed in the theory and business practice of managing energy sector enterprises [1].

Many management theory creators show companies that succeed by applying certain theories while ignoring those in which the theory has failed. The fascination with utilizing successful enterprises as examples and their best practices as case studies is the main reason why new theories emerge quickly and disappear just as quickly, failing to remain popular for a long time. The usefulness of various early management theories is now confronted by challenges in the current turbulent environment [10].

Undoubtedly, there are difficulties in managing energy sector enterprises in the current environment, especially in these turbulent times within energy firms. Management decisions in many cases have not brought the anticipated outcomes. Managers are thus overwhelmed by the numerous problems that their businesses face that do not give in to solution methods and processes, despite the fact that these methods and processes are rooted in present theories on analogous problems [11]. Such a state of affairs has prompted users and creators of the management theory to answer some questions, namely: What are effective methods and research approaches for studying the energy sector comprehensively? By which methods—quantitative or qualitative—is the energy sector predominantly studied?

According to Linnenluecke et al., the literature reviews perform an important role in academic research for collecting present knowledge and for exploring the state of a field [12]. The research methodology should be adjusted to the expected goal and scope of the study [13]. With a constantly growing bulk of knowledge in different subdisciplines of management sciences, there is a growing demand for the consolidation, organization and

synthesis of the existing knowledge [14–17]. Review articles are considered as playing a vital role in the advancement of a collected body of knowledge and in directing upcoming research endeavors. Additionally, they significantly contribute to creating a bulk of knowledge that is central for evidence-based management useful for policymakers and practitioners [18]. The most frequently performed reviews in the energy sector are:

- Systematic Literature Review (SLR);
- Bibliometric literature review;
- Content analysis.

2.1. Systematic Literature Review (SLR)

The first mentioned literature review technique is a Systematic Literature Review. A systematic review can be either quantitative or qualitative. A quantitative systematic review will include studies that have numerical data. A qualitative systematic review derives data from observation, interviews or verbal interactions and focuses on the meanings and interpretations of the participants [19–22]. Three methodological approaches differentiate systematic literature reviews from traditional ones, namely: "(1) they start with delineating a research strategy; (2) they identify explicit criteria for including and/or excluding the literature; and (3) they seek to gather, evaluate, and interpret as much available and relevant literature as possible" [23]. The mentioned approaches are quite useful in dealing with the limitations of the generalization of a traditional review, among others, in "scope (i.e., number of articles reviewed) and nature (i.e., unstructured protocol and reduced replicability) which, because of bias, may produce inconsistencies among reviews of the same topic" [24].

In many papers, SLRs concerning topics in the energy sector have been completed [25]. We can find the literature review regarding the Life Cycle Sustainability Assessment (LCSA) application in the energy field. The energy sector operates as a platform for LCSA usage and methodological progress, as studies utilizing this methodology in energy-related systems have increased significantly over the years [26]. Realizing that volatility is vital for energy sector planning, some review studies examine whether the Heston pricing model is beneficial for foreseeing energy production [27]. We also found review papers exploring the latest approaches in combining Artificial Intelligence and Analytics (AIA) in energy smart grid projects [28–30]. Many reviews concern environmental issues in the context of investments in the energy sector [31–34]. Nowadays, Corporate Social Responsibility (CSR) plays an increasingly important role in company management, including in the energy sector, by forcing them to act beyond the regulatory framework and to orient themselves on their impact on society. CSR is also used by entrepreneurs as a response to requests or requests sent by their stakeholders. [35–39]. Renewable Energy (RE) has been considered as a valuable topic for reviews due to the fact that a large portion of greenhouse gas emissions is ascribed to the energy sector, [40–43].

2.2. Bibliometric Literature Review

Bibliometric analysis belongs to the second-mentioned above group of techniques to conduct literature reviews of various fields of science. This technique is employed to assess the published scientific publications using quantitative, performance and structural indicators to illustrate a panorama of progress in a specific field of science [44]. The obtained data can be used to find the tendency in publication history and distribution, research themes, subject category distribution, leading authors, institutions, journals and countries.

A bibliometric literature review regarding topics in the energy sector was performed in many papers. As the emissions of CO_2—specifically from the energy sector—have risen by 1.7% recently, which is a colossal boost, numerous resources have been utilized to describe the released CO_2, involving a quantitative review of the progress of this topic [44]. Additionally, the energy sector has been studied in the use of prospective scenarios using the bibliometrix R tool and blockchain technology [45,46]. As energy demands and consumption are foremost among global challenges, many bibliometric reviews also re-

fer to the above problem. Specifically, currently the energy consumption model of most households, organizations, industries and nations has been modified, as the energy sector delivers fuel for the majority of the activities in every occupation [33,47]). Furthermore, the main dimensions of Public–Private Partnerships (PPPs) in the energy sector were also examined [48]. What is more, analyses of RD investments in energy and studies on energy technology, environmental aspects, nanotechnology and global climate changes are among the main topics covered in the most cited articles and provide a promising and perspective research field in the energy sector [49,50].

2.3. Content Analysis

Content analysis is the last-mentioned literature review technique. It is utilized to illustrate the scenery of the most numerous keywords applied in a particular field. This technique is used to determine how a specific field has emerged through different areas and what has been the correlation between any two specific keywords [51]. Content analysis can be defined as "an objective, rule-guided technique used to make replicable and valid inferences by analyzing (coding) the characteristics of visual, verbal, and/or written documents" [52]. To obtain greater methodological rigor, qualitative data were changed into quantitative data through systematic evaluation. To obtain a quantitative analysis, it is possible to transform qualitative data through a systematic evaluation. The above may increase the rigor of the methodological review. Another advantage of content analysis is a clear framework that allows the description, understanding and evaluation of the topic, which allows for its unlimited interdisciplinary application in various fields [53].

A content analysis regarding topics in the energy sector was performed in few papers. Using this method, CO_2 emissions from the energy sector were investigated [44]. Additionally, a thorough analysis of the global energy sector's development and the connection between the Rare Earth Metals (REM) market and modern green technologies was performed, leading to the conceptual framework for the development of the REM industry in the context of recent global tendencies [54]. Using these methods, many papers showed the results of an examination of price instability in the energy sector, alongside an exploration of various megatrends impacting oil and gas enterprises [55]. Some articles also focused on recognizing the roles of market-based control on the renewable energy sector, specifically biogas [56]. Thanks to these methods in some papers, researchers were able to identify the reasons of claims faced by clients, contractors and consultants in energy sector mega construction projects in South Africa [57] and to show the misunderstandings between Public–Private Partnerships (PPPs) in the energy sector that have been underlined as a constraining component for the full and effective realization of the projects [48].

The findings of the research showed that both quantitative and qualitative research methodologies received quite good attention in the articles published in the above-mentioned literature reviews. In the energy sector, qualitative methods seem to be more popular, as this method is typically elastic compared with the quantitative method, thus enabling better adjustment and spontaneity of the interface between the research and the researcher [58]. In the next step of our study, we decided to gain more insight into the qualitative, quantitative and relational aspects of the research methodologies and orientations of the articles issued in scientific journals.

3. Research Methodology

Our review paper is based on a comprehensive literature review and qualitative analysis rooted in creative coding [59]. We decided to focus on analyzing recent (i.e., published since 2010) and influential (i.e., widely cited) scholarly texts such as academic journal papers or book chapters from top academic publishing houses. To identify texts, we employed the Scopus database, which is advertised as an updated daily "source-neutral abstract and citation database, curated by independent subject matter experts". Moreover, Scopus (Elsevier) is the database that efficiently covers publications in the field of social

sciences and humanities, which is not the case of the Web of Science by Clarivate (formerly Thompson Reuters) that focuses more on hard sciences and technology.

The search for the relevant texts was carried out via two complementary paths; for both paths, "energy sector" remains the mandatory search term. One search employed the keywords suggested by the *Special Issue of Energies* call for papers itself: Special Issue of Energies (ISSN 1996-1073) "Managing Energy Sector Enterprises: Challenges, Methods and Research Trends" (https://www.mdpi.com/journal/energies/special_issues/Managing_Energy_Sector_Enterprises accessed on 15 June 2022). All these exact terms (e.g., strategic management, innovations management, organizational restructuring or strategy) were searched through the Scopus database (exemplary query line: ALL ("strategic management" AND "energy sector") AND PUBYEAR AFT 1999, where PUBYEAR AFT 2009 stays for Publication year after 2009, which covers all publications since 2010; ALL stays for all search fields, including title, abstract and the main text).

The second path was defined by a more general search of the texts discussing "energy sector" and "management" (query string ALL ("management" AND "energy sector") AND PUBYEAR AFT 1999). The result of the search was 27,595 texts (all data as of 1 December 2021). From the list of keywords provided by Scopus itself, we selected only those terms that have direct connections with the concept of management as such and/or the research methods applicable to energy sector management, with at least 280 texts using particular keywords. The results of the Scopus keywords' examination resulted in another set of texts that reflected some specific aspects of management in the energy sector (see right column of Table 1). It is worth noticing that some keywords appeared no matter which search path was applied, e.g., risk management, strategic management, Artificial Intelligence (AI), thus demonstrating that the call for papers accurately captured the complexity of the management issues in the energy sector. It is also necessary to notice that the keywords used by the Scopus database were defined in a twofold way; some of them were just the keywords provided by the authors of published papers, others were ascribed by Scopus itself according to their policies on the analysis of the content of the text. Due to the Scopus policy, all the texts responded to the common pattern of attributing the keywords.

Table 1. Search terms (keywords) for Scopus database applied. Source: own study.

Terms Defined by the Call for Papers	Terms Defined by Keywords Pertaining to Management, Resulting from General Search (Terms from the Call for Papers Excluded)
Artificial Intelligence (AI)	Correlation analysis
Bibliometric analysis	Cost benefit analysis
Big data analysis	Cost effectiveness
Business models	Decision making
Comparative analysis	Design methodology approach
Energy sector companies	Economic analysis
Innovations management	Economic and social effects
International management	Energy market
Managerial accounting	Energy management
Marketing	Energy planning
Organization and management	Forecasting
Organizational restructuring	Information management
Research methods	Optimization
Risk management	Public policy
Stakeholders	Regression analysis
Strategic management	Risk assessment
Strategy	Scenario analysis
Systematic literature review	
Systems management	

Having defined the keywords for a detailed search of the Scopus database, we identified three most cited texts (papers or book chapters) for each of the keywords provided

in Table 1. Reflecting the interdisciplinary nature of the research into the management issues in the energy sector, many of the texts were ascribed two or more keywords; e.g., "From Nonrenewable to Renewable Energy and Its Impact on Economic Growth: The role of Research and Development Expenditures in Asia-Pacific Economic Cooperation Countries" (keywords: "economic and social effects" and "economic analysis"); "Powered by blockchain: forecasting blockchain use in the electricity market" (keywords: "design methodology approach" and "systems management"); "Modelling and forecasting fossil fuels, CO_2 and electricity prices and their volatilities" (keywords: "economic analysis", "risk management", and "risk assessment"). Eventually, due to such a cross-attribution of keywords, the actual number of analyzed texts was limited to 77, which means that for each of the identified keywords we examined three most cited texts.

To facilitate the work and to enhance the objectivity of the results, we employed MAXQDA2020 software as the tool to support the conducted qualitative research. The qualitative coding, assisted by Computer-Assisted Qualitative Data Analysis Software (CAQDAS), enabled unbiased and thorough content analysis of the text selected according to the procedure described above. MAXQDA2020 software enables the automatization of searches through the context of the texts analyzed, thus reducing the possibility of mistakes or accidental omissions and securing the validity of the results. Moreover, MAXQDA2020 offers tools for a collaborative project and provides necessary assistance in examining large numbers of documents. Finally, the software facilitates double checking of coding. The automatization of the research was possible thanks to a Lexical search tool, accompanied by the lemmatization option (lemmatization treats such terms as "management" or "managing" as a single basic dictionary form).

The employed search terms are presented in Table 2. They reflect three basic groups. The first group, represented by the search terms "energy sector" and "management/managing", corresponds with the topic of the mentioned special issue of *Energies*. The second group reflects the attributes or qualities of management (e.g., performance, efficiency). The last group reflects the attributes or qualities of the research methods employed in the analyzed texts (e.g., matrix, advanced, method).

Table 2. Lexical search terms applied to the texts analyzed. Source: own study.

Search Term	Number of Occurrences (Coded Segments)
Energy sector	743
Management/managing	1107
Performance	482
Efficiency	934
Complex	180
Innovation/innovative	431
Advanced	204
Approach	659
Matrix	69
Method	726
Analysis	1276
Research	1259

4. Analysis of Collected Data

4.1. Overview

The complexity of the topic discussed in the special issue of *Energies*: "Managing Energy Sector Enterprises: Challenges, Methods and Research Trends" is well captured by the word cloud created by the analysis of the 77 selected texts (see Figure 1 and Table A1). The new challenges of the sector cover urgent issues such as climate change (terms: climate, change, environment); sustainability (renewable, sustainable, growth); challenges and expectations of energy market (consumption, production, market); most importantly, methods and approaches in analyzing and responding to the challenges (analysis, study, model, data). It is not surprising that the word recurring most frequently is "energy" (12,808 hits),

which is almost five times more frequent than the second entry on the word cloud "renewable" (2718 hits). Interestingly, the terms directly connected to the research/analysis processes—data, analysis, research—have a very similar number of hits (respectively, 1534, 1525 and 1516), locating them at places 8–10 on the list.

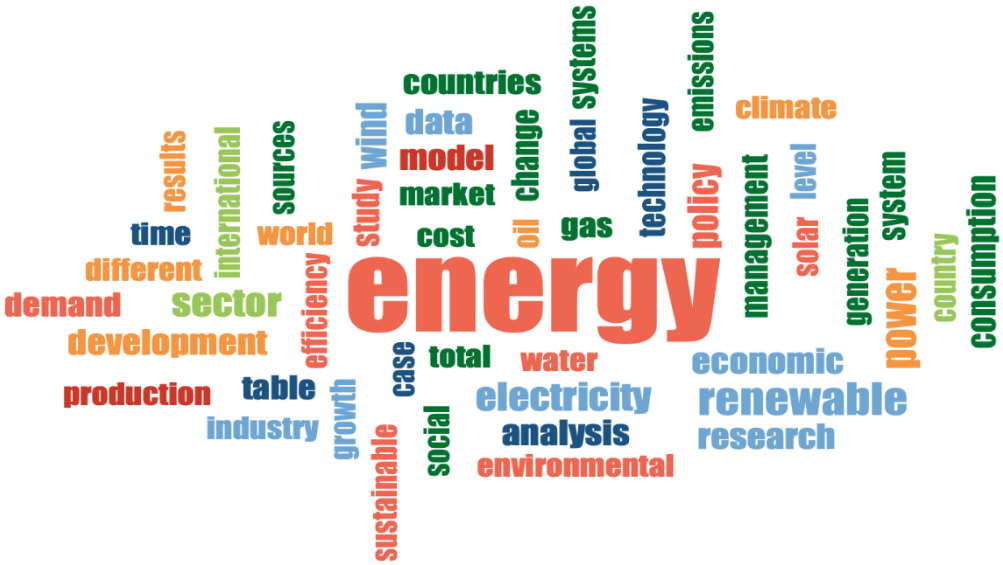

Figure 1. Word cloud (based on 77 analyzed documents). Source: own study.

The structure of the word cloud proves that the issue of the energy sector itself, focusing on power and electricity, was far more important for the authors of the analyzed texts than the methods of research/analysis employed in these texts. Thus, the word cloud reflects an understandable and responsible academic approach when the problem to be solved is more important than the method itself [60].

The MAXQDA2020 software facilitates the general overview of the code distribution (code matrix browser) by showing the code saturation (i.e., how many coded segments a text contains). Thus, the code matrix browser visualizes which codes have been assigned to which analyzed document and in such a way enables the examination of how many segments were assigned a specific code. The larger the dot, the more coded segments were assigned in a document. The visual analysis, reflected in Figure A1 in the Appendix A, shows that, for most of the texts, the word "analysis" was the key term to describe the authors' approach to investigating problems pertaining to energy sector management. Despite the complexity of the research problem, supporting the investigation by applying matrices that could help handle different characteristics and/or factors that influence both energy production and consumption and the management itself.

On the other hand, Figure A1 shows that some of the papers and book chapters explored the methods and approaches more diligently and investigated not only the energy sector management as the research problem but also the research procedures and the validity of the achieved results. The paper "Drivers that motivate energy companies to be responsible. A systematic literature review of Corporate Social Responsibility in the energy sector" contains 83 segments coded as "analysis" and 54 segments coded as "approach". The paper "Review of technology acquisition and adoption research in the energy sector" contains 50 segments coded as "analysis" and 40 segments coded as "method". "A review of Dynamic Data Envelopment Analysis: state of the art and applications" contains 89 segments coded as "analysis", 30 coded as "approach" and 17 as "method". Thus, the MAXQDA visual tool proved that the text titles that suggested focusing on research methods and approaches were concentrating on the problem of reaching solid and well-grounded results. The only paper with a title not suggesting a special focus on research methods and approaches is "100% Clean and Renewable Wind, Water, and Sunlight All-Sector Energy Roadmaps for 139 Countries of the World". Although its main

aim is to sketch out the roadmaps for generating greener energy, the paper also explores "analysis" (65 coded segments), "method" (29 segments) and "approach" (6 segments).

Another visual tool of the MAXQDA software, that enables taking a broader perspective, is the code relations browser. It shows how often segments (sentences) are coded with overlapping codes (e.g., the same fragment is coded as "method" and "approach"). Figure 2 proves that most common concurrences were between "analysis" and "method" (170 segments shared these two codes), "analysis" and "management/managing" (142 segments shared these two codes), "analysis" and "efficiency" (140 segments shared these two codes), "approach" and "method" (129 segments shared these two codes), "analysis" and "approach" (123 segments shared these two codes), "analysis" and "energy sector" (119 segments shared these two codes), "method" and "management/managing" (114 segments shared these two codes) and "efficiency" and "management/managing" (114 segments shared these two codes). On the other hand, the code relations browser proves that, in the analyzed texts, there is very weak correlation between the term "matrix" and all other codes. This means that, despite the initial assumptions of the importance of the term "matrix" in researching the energy sector, the top publications do not employ it as a key component of the research methods.

Code system	research	energy sector	management/managing	performance	efficiency	complex	innovation/innovative	advanced	approach	matrix	method	analysis
research	0	143	181	59	113	28	80	38	92	5	138	197
energy sector	143	0	86	41	89	22	64	30	52	2	61	119
management/managing	181	86	0	72	114	38	92	29	100	18	114	142
performance	59	41	72	0	71	10	25	11	42	6	33	94
efficiency	113	89	114	71	0	21	29	50	91	4	72	140
complex	28	22	38	10	21	0	6	4	22	0	23	29
innovation/innovative	80	64	92	25	29	6	0	18	38	3	14	59
advanced	38	30	29	11	50	4	18	0	15	0	16	27
approach	92	52	100	42	91	22	38	15	0	4	129	123
matrix	5	2	18	6	4	0	3	0	4	0	12	8
method	138	61	114	33	72	23	14	16	129	12	0	170
analysis	197	119	142	94	140	29	59	27	123	8	170	0

Figure 2. Code relations browser (the columns repeat rows, therefore the intersection of a row and column of the same code is always blank). Source: own study.

The code relations browser, as a visual tool, proves a very strong correlation between "analysis", "method" and "research". Thus, the publications reflect a growing understanding for well-organized research into the energy sector to secure efficiency in managing the sector.

The result of employing the MAXQDA2020 code relations browser demonstrates that the selected texts treated the research method/approach with due consideration. Discussed fragments employed in the texts intended to respond to the requirements of the academic journals and the publishing houses. Thus, the authors not only analyzed complex problems of the energy sector and efficient energy sector management but also, with equal attention, they investigated the way these complex problems should be approached, discussed and explained. A recurring problem, explored by many analyzed papers, is the complexity of researching energy sector management, which is also reflected by various theoretical and practical approaches [61]. The complexity of the problem is partially the result of a variety of academic disciplines (all belonging to management and business) that should be taken into consideration, such as "product development, project management, and resource management" [62].

4.2. Research Methods' Mix

The fields of economy, management and business studies must incorporate various research methods, mostly because they try to comprehend and explain human behavior by employing methodical and rational tools of investigation. Therefore, as the authors of "Review of technology acquisition and adoption research in the energy sector" observe, "methods that suit this economic subcategory involve Cost-Benefit Analysis, Industrial Economics, and Real Options. Additional general subcategory includes Performance & Flexibility metrics linked to the planning and execution of new technologies. Methods in this subcategory include Decisions Support/Expert Systems, Project & Process Management, and Statistical Analysis. Some of these methodologies may overlap, at least partly, into more than one category or subcategory. Both economics and flexibility related measures play vital roles in establishing and assessing new technologies within an organization so that an adoption decision can be made" [62]. The methods "may overlap" sometimes, but, thanks to such overlapping, researchers can achieve greater reliability and consistency in the results.

One of the reasons why so many different research methods should be employed is the complicated nature of the energy sector management itself. The research problem is located at the intersection of more hard-science types of problems (e.g., energy production and distribution, financial efficiencies of public policies) and more humane socially relevant problems (e.g., social expectations, consumers' behavior). Another opportunity for further research that can be of interest to management studies is a deeper examination of the "link between attending to social expectations and the fulfillment of strategic business objectives in the energy sector" [63]. Thus, the interrelation of "social expectations" and "strategic business objectives in the energy sector" becomes an even more important challenge for future research, especially considering that challenges brought on by climate change and the urgency of achieving United Nations' Strategic Development Goals (especially SDG and access to affordable, reliable, sustainable and modern energy for all) call for a more humanistic approach in managing the energy sector, which should not focus only on narrowly understood economic efficiency.

The presence of people and real persons must always be part of the equation. Decisions, both economic and political, concerning energy should be open to a broader participation of those who would eventually benefit (or suffer) from what is decided by companies and/or governments. Therefore, "the methodology for selecting C&I [criteria and indicators] can be combined with participatory C&I prioritization to determine the relative importance of each criterion and its indicator. This can help to improve performance assessments of selected C&I and support participatory decision making" [64].

However, for many years—as the paper on Polish enterprises in the energy sector rightly summarizes—the social factor has been overlooked by companies in the energy sector. Because of its close relatedness to both the tradition and the history of a company as well as the existing management methods, it may have a unique form depending on the enterprise. According to the general definition, corporate culture may be assumed as "a specific way of seeing reality by employees, which results from the same beliefs, principles and values that were adopted during a common performance of professional tasks and duties within an organization" [65]. The organizational changes, adoption of new technology and general ease in accepting new responsibilities (including social responsibility) is always rooted in culture and in some unwritten rules; thus, understanding "values, expectations, and assumptions" plays a vital role in managing energy sector companies [66].

4.3. Energy Sector Interdependencies

The social dimension of the impact of the energy sector suggests the application of qualitative studies (such as participatory criteria selection), yet research employing quantitative methods could still boost the effectiveness of managerial decision making. As the studies show, quantitative methods help "to define the modeling elements (variables,

parameters, constraints and production technologies, among others)" [67]. Therefore, a simple one-sided approach would not help in solving challenges of energy production, distribution, conservation and consumption. This is what the paper "Artificial Intelligence for Smart Renewable Energy Sector in Europe" perfectly explains in a longer fragment, worthy of quoting in extenso [68]:

"The energy sector is a complex set of interdependent connections; therefore, it requires multidisciplinary approach. It is not only investigating the way the energy is produced, the means utilized to transmit power but also the patterns of energy consumptions. Thus, the validity of the research must be based on combining hard sciences (such as physics), engineering (computer science) and social sciences (economics, management, or sociology).

Given the multidisciplinary nature of this research and our key objective to integrate advanced computer science research with economics and smart cities research the key aspects of our research methodology are as follows:

(1) The understanding of macro-economic contribution to the debate on Smart Girds and Renewable Energy [RE] domain.
(2) The integration of advanced Artificial Intelligence components to the research model, recognizing AI as a research domain with key impact on efficiency and performance on Smart grids and RE.
(3) The combined impact of macro-economic factors and AI value propositions to resilient Smart Cities research".

The complexity of factors shaping the energy sector and influencing decision making (both political and managerial) makes the use of Artificial Intelligence an obvious choice. The quest for a more stable and sustainable energy sector should also include the application of Artificial Intelligence, thus facilitating "personalization and parametrization of consumption and production" [68]. AI might be especially important in analyzing the social factors, since the energy sector and access to "affordable energy" should not be limited only to the technical capabilities of the energy grid: "AI algorithms in the Energy sectors requires the analysis of social and economic factors beyond the technical capabilities. Different AI approaches including management of structured data, data mining capabilities and machine learning techniques, can support an AI eco-system or a system of systems within the energy sector promoting an AI enabled Smart Energy Grid" [68].

Research into the energy sector has very practical implications—as the majority of the papers emphasize—and the results of the research should strengthen the evidence-based decision-making approach. Thanks to the research being organized in such a way, both policymakers and managers could sketch the roadmaps for further improvements and developments of the energy sector: "Our analysis indicates that there are multiple approaches, methodologies and tools used to develop renewable technology roadmaps. During the last decade there is a significant worldwide increase in use of roadmaps for the renewable energy sector. We also have seen several methodological improvements in development of different types of technology roadmaps" [69].

The energy sector is populated by a plethora of players, some of whom play key parts, while some only have minor roles. For example, to understand the peak electricity demand, a researcher and an informed manager must take into consideration a complex network of interdependent and semi-independent actors. In turn, managing the peak electricity demand requires a deeper understanding of the social behavior of consumers. These interactions between demand and supply stay mostly uncovered in the policy and strategy repositories that prevail in the energy sector. A practice theory view inspires to end the individual "roles and responsibilities of 'suppliers' and 'demanders', to critically examine how electricity systems uphold or challenge existing (problematic) needs, and how they can potentially enable innovative co-management opportunities" [70].

Such an open-minded approach is especially important in regions where the energy sector is underdeveloped. These regions (and the challenges they face) call for more flexibility than is offered by quantitative research, as the authors of an article on Afghan electrical energy posit. In their research, a qualitative research approach was utilized that

concentrated on the literature review and the analysis of published materials that were linked to Afghan electrical energy and trans-boundary water. Among the main reasons for selecting the mentioned research methodology, they mentioned the nature of the study and the possibility of better addressing the intentions and approaches of decision making in the studied sector rather than utilizing a quantitative method.

5. Discussion

The 77 texts we have analyzed prove that the energy sector management is of growing importance, both as a research problem and as a challenge faced by the modern world. The variety of methods and approaches employed by these texts reflect the ever-growing complexity of the energy sector. This is one of the reasons why so many researchers recur to qualitative methods; although, quantitative methods seem to be suitable for informed decision making. The keynote in creating this article was the lack of similar research on the review of research methods in the energy sector in the literature on the subject.

The code map presented in Figure 3 shows how closely connected and interdependent "energy sector", "management", "research", "analysis" and "efficiency" are. Each dot symbolizes a code, while the size of the circle and the print reflect the code saturation. The distance between two codes represents how similarly these two codes are distributed throughout the analyzed texts. Finally, the thickness of the line reflects the number of coincidences between two codes [71]. The results presented in Figure 3 prove that there is a strong correlation between research/analysis and management. Thus, recent publications on the energy sector leave no doubt that well informed decision making and management could not exist without thorough analyses and research, although the emphasis on research should not be limited to the quest for efficiency.

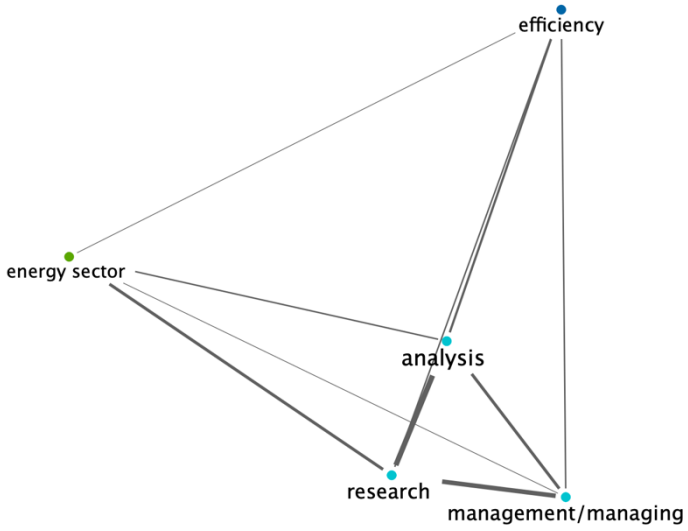

Figure 3. Code map (node size by number of occurrences). Source: own study.

Economic efficiency should not be the ultimate goal of the energy sector; it has a much broader social impact. The analyzed papers share a common assumption that the energy sector will play a vital role in social and economic development in the decades to come and that there would be no future for the energy sector (and a rather sad perspective for the planet) without continuing and expending research into the energy sector. The problems of reduction (or, most preferably, elimination) of greenhouse gases, the expansion of green energy and further development of electromobility all require even greater attention of researchers and policymakers. The future of the planet and of humankind depends on how we will produce, store and consume energy. This is the reason why foresight and the Delphi method are of great interest for managers of the energy sector.

Some researchers applied the Delphi method "to create a vision of the energy sector of Poland till 2030" with an aim to provide direction for energy sector development in the future and to ensure energy security [41].

Although informed managerial decision making should be supported by quantitative methods, the complexity of the energy sector does not exclude a qualitative approach. There are regions and/or problems that call for more flexibility than is offered by quantitative research, as the authors of a paper on Afghan electrical energy explain:

> "This research has been developed pursuing qualitative research approach based on the review and analysis of literature such as books, journal articles, reports, and conferences related to Afghanistan electrical energy and trans-boundary water. The reasons behind selecting this methodology come from the nature of the study as it covers the overall analysis and in-depth understanding of implicit facts in the energy sector and examines the reasons and ways of decisions making in the mentioned sector which can be addressed better based on this method than quantitative one. In addition, the qualitative method is characteristically flexible compared to quantitative method, so it facilitates better adjustment and spontaneity of the interface amongst the study and the researcher. Hence, the qualitative method is more appropriate in this regard" [58].

Countries with well-developed and stable energy sectors—especially those with an abundance of resources—sometimes demonstrate a disturbing relaxation; they do not see how important the problem of securing sustainable and fair energy production is. The production and the use of energy have a global impact, easily crossing political borders. Therefore, the research into the energy sector should also contribute "to the ongoing debate concerning the potential effects of resource abundance. More importantly, it increases our understanding of innovation activities within the energy sector and further underscores the need to extend future research to countries that have not been taken into account thus far" [72].

To solve the problem of fair access to energy is no longer the problem of just a few developed countries. This has become a global issue, as clearly stated by the United Nations Sustainable Development Goals. Thus, it calls for innovative approaches for managing the energy sector, remembering that innovation is no longer the domain of the Global North (rich and developed countries). "As non-OECD members will become more important in the field of international energy politics, we must investigate what drives the innovation process in those countries" [72]. The authors of "CO_2 emission from China's energy sector" make it clear: "Technology innovation is the key approach to improve energy efficiency and economic performance" [73]. Thus, innovation is the key to success, no matter how large or small and powerful or irrelevant the country or the institution is. The University of Genoa, definitely not the largest or most important player in the energy sector, proves that there is space for improvement in energy management everywhere: "Nowadays, as set by the EU 20-20-20 targets, the reduction of primary energy use and greenhouse gas emissions in the energy sector can be attained by increasing the use of renewable sources and improving energy efficiency. Many national and international research programs are aiming at developing innovative technologies and new energy management strategies in order to reach the targets set out in the 20-20-20 directive" [74].

6. Conclusions

This study presents a comprehensive overview of publications on research approaches in the area of managing energy sector enterprises by showing a descriptive and content analysis of published articles in the Scopus database. Initially, the terms and criteria used in a given database were defined. The above allowed for the isolation and identification of publications and their analysis in accordance with the criteria described. The analysis included 77 articles.

As a result of the undertaken research on the listed articles in the energy sector, we observed a trend among researchers to focus on creating systematic and bibliometric

reviews of the literature, including content analysis. First, one of the reasons why so many different methods should be employed is the complicated nature of the energy sector management itself. Second, the social factor should not be overlooked by companies of the energy sector. The social dimension of the impact of the energy sector suggests the application of qualitative studies (such as participatory criteria selection). Nevertheless, the use of both qualitative research and quantitative methods can boost the effectiveness of managerial decision making in this sector.

Through a more in-depth study of the articles—not only by including key words—our research allowed to fill the theoretical gap in the energy sector from the perspective of a management sciences discipline, pointing to the strong correlation between "analysis", "method" and "research". The publications therefore reflect the growing understanding of well-structured energy research, ensuring efficient management of the sector.

With this paper, we also answered the call formulated by Parisa Maroufkhani, Kevin C. Desouza, Robert K. Perrons and Mohammad Iranmanesh in their article "Digital transformation in the resource and energy sectors: A systematic review" [6] to conduct a systematic literature review and to provide for research the methods used most frequently in the energy sector formulated in the article "The importance of Mix Methodology for Studying Offshore Energy sector" [7].

Each study is also associated with certain limitations that affect the presentation of the results; therefore, some generalizations and incompleteness of the data used cannot be avoided. To ensure the same level of publication, we limited our research to one database, not including publications published in any database other than Scopus.

In this research, trade magazines and monographs could be a source of valuable information as they are often focused on specific sectors and practical aspects. An extension to this article could be to take into account the above-mentioned articles, in particular their substantive contribution in the context of the energy sector research. A subjective approach was used in the process of selecting publications, which at the same time could translate into the erroneous omission of some important articles during the selection.

In conclusion, we would like to draw the attention of future researchers to the issue of the selection of publications and to take into account a wider sample (e.g., employing databases other than Scopus) in order to possibly update the results presented in this article. We would like to emphasize that a given publication may constitute a basis for further research, both theoretical and practical, or may constitute a compendium of knowledge on a given topic.

Author Contributions: Conceptualization M.S., R.R. and J.B.; methodology M.S., R.R. and K.B.; software R.R. and K.B.; validation R.R. and J.B.; formal analysis M.S., R.R., K.B. and J.B.; resources R.R., K.B. and J.B.; writing—original draft preparation M.S., R.R., K.B. and J.B.; writing—review and editing M.S., R.R., K.B. and J.B.; funding acquisition M.S. and K.B. The contribution share of authors is equal and amounted to 25% for each of them. All authors have read and agreed to the published version of the manuscript.

Funding: The study was co-financed from the subsidy granted to the Cracow University of Economics, grant no. 055/ZZA/2022/POT and grant no. 035/SD/2022/PRO.

Data Availability Statement: The data used in this study is publicly available and sources are referred.

Acknowledgments: We would like to thank the anonymous reviewers for their constructive comments, which have led to meaningful improvements in the paper.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

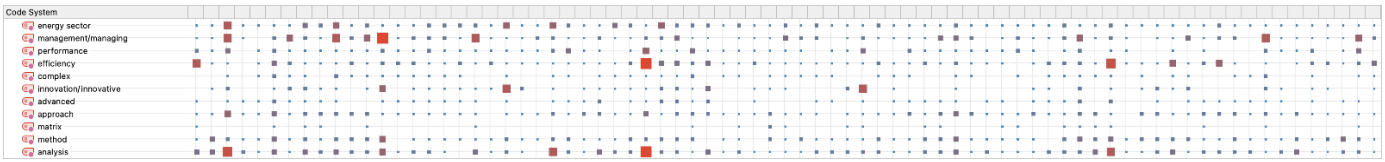

Figure A1. Code matrix browser (reflecting the distribution of codes across the analyzed texts; the rows are the codes applied with the use of a lexical search; the columns represent subsequent texts; due to the figure size the titles were not provided here). Source: own study.

Appendix B

Table A1. List of analyzed texts (in chronological order). Source: own study.

Title	Author	Journal	Year
Application of technology roadmaps for renewable energy sector	Muhammad Amer and Tugrul U. Daim	*Technological Forecasting and Social Change*	2010
System Architecture of a Modular Direct-DC PV Charging Station for Plug-in Electric Vehicles	Christopher Hamilton et al.,	ECON 2010: 36th Annual Conference on IEEE Industrial Electronics Society	2010
Energy access in Africa: Challenges ahead	Abeeku Brew-Hammond	*Energy Policy*	2010
Scenario analysis using Bayesian networks: A case study in energy sector	Didem Cinar and Gulgun Kayakutlu	*Knowledge-Based Systems*	2010
CO_2 emission from China's energy sector and strategy for its control	Jiankun He and Jing Deng, Mingshan Su	*Energy*	2010
An Integrated Security System of Protecting Smart Grid against Cyber Attacks	Dong Wei, Member et al.,	*IEEE Access*	2010
Energy access in Africa: Challenges ahead	Abeeku Brew-Hammond	*Energy Policy*	2010
Sustainable energy systems: Role of optimization modeling techniques in power generation and supply—A review	Aqeel Ahmed Bazmi and Gholamreza Zahedi	*Renewable and Sustainable Energy Reviews*	2011
Review of technology acquisition and adoption research in the energy sector	Kelly R. Cowan and Tugrul U. Daim	*Technology in Society*	2011
Energy policy and European utilities' strategy: Lessons from the liberalisation and privatisation of the energy sector in Romania	Laura N. Haar and Nicolae Marinescu	*Energy Policy*	2011
Development and commercialization of renewable energy technologies in Canada: An innovation system perspective	Kalinga Jagoda et al.,	*Renewable Energy*	2011
Energy Supply Risk Premium: Review and Methodological Framework	Antonis Skouloudis et al.,	*Energy Sources, Part B: Economics, Planning, and Policy*	2011
Project finance risk evaluation of the Electric power industry of Serbia	Dragana Makajic Nikolic et al.,	*Energy Policy*	2011
Solar water heating initiative in Oman energy saving and carbon credits	Adel Gastli and Yassine Charabi	*Renewable and Sustainable Energy Reviews*	2011
Component sizing optimization of plug-in hybrid electric vehicles	Xiaolan Wu et al.,	*Applied Energy*	2011
SCMS—Semantifying Content Management Systems	Axel-Cyrille Ngonga Ngomo et al.,	International Semantic Web Conference	2011
The long-term forecast of Taiwan's energy supply and demand: LEAP model application	Huang Yophya et al.,	*Energy Policy*	2011

Table A1. *Cont.*

Title	Author	Journal	Year
Electricity consumption and economic growth nexus in Bangladesh: Revisited evidences	Mazbahul Golam Ahamad and Nazrul Islam	*Energy Policy*	2011
Contributing to local policy making on GHG emission reduction through inventorying and attribution: A case study of Shenyang, China	Fengming Xi et al.,	*Energy Policy*	2011
Natural drying treatments during seasonal storage of wood for bioenergy in different European locations	Dominik Röser et al.,	*Biomass and Bioenergy*	2011
Peak electricity demand and social practice theories: Reframing the role of change agents in the energy sector	Yolande Strengers	*Energy Policy*	2012
European climate—energy security nexus: A model based scenario analysis	Patrick Criqui and Silvana Mima	*Energy Policy*	2012
Total Site targeting with process specific minimum temperature difference	Petar Sabev Varbanov et al.,	*Energy*	2012
Energy sector vulnerability to climate change: A review	Roberto Schaeffer et al.,	*Energy*	2012
Co-movement of energy commodities revisited: Evidence from wavelet coherence analysis	Lukas Vacha and Jozef Barunik	*Energy Economics*	2012
What drives the change in China's energy intensity: Combining decomposition analysis and econometric analysis at the provincial level	Feng Song and Xinye Zheng	*Energy Policy*	2012
Long run energy demand in Iran: a scenario analysis	Saeed Moshiri et al.,	*International Journal of Energy Sector Management*	2012
Participatory selection of sustainability criteria and indicators for bioenergy developments	Thomas Kurka and David Blackwood	*Renewable and Sustainable Energy Reviews*	2013
Modelling and forecasting fossil fuels, CO_2 and electricity prices and their volatilities	Carolina García-Martos et al.,	*Applied Energy*	2013
The role of governments in renewable energy: The importance of policy consistency	William White et al.,	*Biomass and Bioenergy*	2013
NOAA's Second-Generation Global Medium-Range Ensemble Reforecast Dataset	Thomas Hamill et al.,	*Environmental Science*	2013
Australian renewable energy policy: Barriers and challenges	Liam Byrnes et al.,	*Renewable Energy*	2013
The University of Genoa smart polygeneration microgrid test-bed facility: The overall system, the technologies and the research challenges	Stefano Bracco et al.,	*Renewable and Sustainable Energy Reviews*	2013
Managing stakeholder relations when developing sustainable business models: the case of the Brazilian energy sector	Stelvia Matos and Bruno S. Silvestre	*Journal of Cleaner Production*	2013
Competitive and responsible? The relationship between corporate social and financial performance in the energy sector	Satu Pätäri et al.,	*Renewable and Sustainable Energy Reviews*	2014
Renewable energy consumption—Economic growth nexus for China	Boqiang Lin and Mohamed Moubarak	*Renewable and Sustainable Energy Reviews*	2014
Geologic storage of hydrogen: Scaling up to meet city transportation demands	Anna S. Lord et al.,	*International Journal of Hydrogen Energy*	2014

Table A1. *Cont.*

Title	Author	Journal	Year
Human behaviour in household energy use and the implications of energy efficiency delivery: A case of Bauchi, Nigeria	Ibrahim Udale Hussaini and Noor Hanita Abdul Majid	*International Journal of Energy Sector Management*	2014
Catalytic reduction of CO_2 by H^2 for synthesis of CO, methanol and hydrocarbons: Challenges and opportunities	Marc Porosoff et al.,	*Energy & Environmental Science*	2015
Renewable energy potential and national policy directions for sustainable development in Morocco	Tarik Kousksou et al.,	*Renewable and Sustainable Energy Reviews*	2015
Stepwise multiple regression method of greenhouse gas emission modeling in the energy sector in Poland	AlicjaKolasa-Wiecek	*Journal of Environmental Sciences*	2015
Fleadapt scale: a new tool to measure frontline employee adaptability in power sector	Michael Sony and Nandakumar Mekoth	*International Journal of Energy Sector Management*	2015
DEA window analysis and Malmquist index to assess energy efficiency and productivity in Jordanian industrial sector	Abbas Al-Refaie et al.,	*Energy Efficiency*	2016
Understanding household energy consumption behavior: The contribution of energy big data analytics	Kaile Zhou and Shanlin Yang	*Renewable and Sustainable Energy Reviews*	2016
Chinese FDI and psychic distance perceptions on regulations in the German renewable energy sector	Katiuscia Vaccarini et al.,	*Energy Policy*	2016
Innovation in the energy sector—The role of fossil fuels and developing economies	Elina Brutschin and Andreas Fleig	*Energy Policy*	2016
Financing the civic energy sector: How financial institutions affect ownership models in Germany and the United Kingdom	Stephen Hall, Timothy J. Foxonb and Ronan Boltonc	*Energy Research & Social Science*	2016
Analysis of renewable energies in European Union	Mihaela Pacesila et al.,	*Renewable and Sustainable Energy Reviews*	2016
A risk assessment tool for improving safety standards and emergency management in Italian onshore wind farms	Davide Astiaso Garcia and Daniele Bruschi	*Sustainable Energy Technologies and Assessments*	2016
The impact of government subsidies and enterprises' R&D investment: A panel data study from renewable energy in China	Feifei Yu et al.,	*Energy Policy*	2016
Corporate Social Responsibility in Energy Sector	Jelena Stjepcevic and Indre Siksnelyte	*Transformations in Business and Economics*	2017
Renewable energy and biodiversity: Implications for transitioning to a Green Economy	Alexandros Gasparatosa et al.,	*Renewable and Sustainable Energy Reviews*	2017
A review of Dynamic Data Envelopment Analysis: state of the art and applications	Fernanda Mariza et al.,	*International Transactions in Operational Research*	2017
100% Clean and Renewable Wind, Water, and Sunlight All-Sector Energy Roadmaps for 139 Countries of the World	Mark Z. Jacobson et al.,	*Joule*	2017
The importance of open data and software: Is energy research lagging behind?	Stefan Pfenningera et al.,	*Energy Policy*	2017
Economic analysis of small wind turbines in residential energy sector in Iran	Ramin Hosseinalizadeh et al.,	*Sustainable Energy Technologies and Assessments*	2017

Table A1. *Cont.*

Title	Author	Journal	Year
Analyzing Sentiments Expressed on Twitter by UK Energy Company Consumers	Victoria Ikoro et al.,	Fifth International Conference on Social Networks Analysis, Management and Security (SNAMS)	2018
How much does financial development contribute to renewable energy growth and upgrading of energy structure in China?	Qiang Ji and Dayong Zhang	*Energy Policy*	2018
Afghanistan electrical energy and trans-boundary water systems analyses: Challenges and opportunities	Saadatullah Ahmadzai and Alastair McKinna	*Energy Reports*	2018
The future of Russia's renewable energy sector: trends, scenarios and policies	Liliana N. Proskuryakova and Georgy V. Ermolenko	*Renewable Energy*	2018
Beyond the Age of Oil and Gas—How artificial intelligence is transforming the energy portfolio of the societies	Karoly Nagy and Edmond Hajrizi	*IFAC-PapersOnLine*	2018
The firm-level innovation impact of public R&D funding: Evidence from the German renewable energy sector	Josef Plank and Claudia Doblinger	*Energy Policy*	2018
From nonrenewable to renewable energy and its impact on economic growth: The role of research & development expenditures in Asia-Pacific Economic Cooperation countries	Muhammad Wasif Zafara et al.,	*Journal of Cleaner Production*	2018
Energy consumption and agricultural economic growth in Pakistan: is there a nexus?	Abbas Ali Chandio et al.,	*International Journal of Energy Sector Management*	2018
Comparison of seven numerical methods for determining Weibull parameters of wind for sustainable energy in Douala, Cameroon	Kengne Signe Elie Bertrand et al.,	*International Journal of Energy Sector Management*	2018
Empirical determinants of renewable energy deployment: A systematic literature review	Clémence Bourcet	*Energy Economics*	2019
Drivers that motivate energy companies to be responsible. A systematic literature review of Corporate Social Responsibility in the energy sector	Latapí Agudelo Mauricio Andrés et al.,	*Journal of Cleaner Production*	2019
Efficiency of Enterprise Risk Management (ERM) systems. Comparative analysis in the fuel sector and energy sector on the basis of Central-European companies listed on the Warsaw Stock Exchange	Izabela Jonek-Kowalska	*Resources Policy*	2019
The impact of market competition on CEO salary in the US energy sector	Panayotis G. Michaelidesa et al.,	*Energy Policy*	2019
Corporate culture versus CSR in Polish companies of the energy sector	Marta Sukiennik and Patrycja Bąk	The 2nd International Conference on the Sustainable Energy and Environmental Development	2019
A Guided Procedure for Governance Institutions to Regulate Funding Requirements of Solar PV Projects	Ameena Saad Al-Sumaiti et al.,	*IEEE Access*	2019
A versatile and membrane-less electrochemical reactor for the electrolysis of water and brine	Mohammad H. Hashemi et al.,	*Energy & Environmental Science*	2019
Greenhouse Gases and Circular Economy Issues in Sustainability Reports from the Energy Sector in the European Union	Agnieszka Janik et al.,	*Energies*	2020

Table A1. *Cont.*

Title	Author	Journal	Year
Artificial Intelligence for Smart Renewable Energy Sector in Europe—Smart Energy Infrastructures for Next Generation Smart Cities	Andreea Claudia Şerban and Miltiadis D. Lytras	*IEEE Access*	2020
Artificial Neural Network and its Applications in the Energy Sector—An Overview	Damilola Elizabeth Babatunde, Ambrose Anozie and James Omoleye	*International Journal of Energy Economics and Policy*	2020
Electrical Demand and its Flexibility in Different Energy Sectors	Muhammad Waseem et al.,	*Electric Power Components and Systems*	2020
Powered by blockchain: forecasting blockchain use in the electricity market	Stefan Höhne and Victor Tiberius	*International Journal of Energy Sector Management*	2020

References

1. Borowski, P.F. New Technologies and Innovative Solutions in the Development Strategies of Energy Enterprises. *HighTech Innov. J.* **2020**, *1*, 39–58. [CrossRef]
2. Prina, M.G.; Manzolini, G.; Moser, D.; Nastasi, B.; Sparber, W. Classification and challenges of bottom-up energy system models–A review. *Renew. Sustain. Energy Rev.* **2020**, *129*, 109917. [CrossRef]
3. Gielen, D.; Boshell, F.; Saygin, D.; Bazilian, M.D.; Wagner, N.; Gorini, R. The role of renewable energy in the global energy transformation. *Energy Strategy Rev.* **2019**, *24*, 38–50. [CrossRef]
4. Meckling, J. Governing renewables: Policy feedback in a global energy transition. *Environ. Plan. C Politics Space* **2019**, *37*, 317–338. [CrossRef]
5. Luangchosiri, N.; Ogawa, T.; Okumura, H.; Ishihara, K.N. Success Factors for the Implementation of Community Renewable Energy in Thailand. *Energies* **2021**, *14*, 4203. [CrossRef]
6. Maroufkhani, P.; Desouza, K.C.; Perrons, R.K.; Iranmanesh, M. Digital transformation in the resource and energy sectors: A systematic review. *Resour. Policy* **2022**, *76*, 102622. [CrossRef]
7. Pego, A.C.H.C.D. The importance of Mix Methodology for Studying Offshore Energy sector. *Int. J. Humanit. Soc. Sci. Invent.* **2016**, *5*, 6–8.
8. Schulze, M.; Nehler, H.; Ottosson, M.; Thollander, P. Energy management in industry—A systematic review of previous findings and an integrative conceptual framework. *J. Clean. Prod.* **2016**, *112*, 3692–3708. [CrossRef]
9. Consumer Prices, OECD—Updated: 4 May 2022—OECD. Available online: https://www.oecd.org/sdd/prices-ppp/consumer-prices-oecd-updated-4-may-2022.htm (accessed on 18 July 2022).
10. Akpor-Robaro, M.O.M.; Erigbe, P.A. Evaluation of the Application of Traditional Western Management Theories in Africa from a Survey of Nigerian Organizations. *Arch. Bus. Res.* **2018**, *6*, 94–111.
11. Jordaan, B. Leading organisations in turbulent times: Towards a different mental model. *Contrib. Manag. Sci.* **2019**, *38*, 59–75. [CrossRef]
12. Linnenluecke, M.K.; Marrone, M.; Singh, A.K. Conducting systematic literature reviews and bibliometric analyses. *Aust. J. Manag.* **2020**, *45*, 175–194. [CrossRef]
13. Dzikuć, M.; Gorączkowska, J.; Piwowar, A.; Dzikuć, M.; Smoleński, R.; Kułyk, P. The analysis of the innovative potential of the energy sector and low-carbon development: A case study for Poland. *Energy Strategy Rev.* **2021**, *38*, 100769. [CrossRef]
14. Cropanzano, R. Writing nonempirical articles for journal of management: General thoughts and suggestions. *J. Manag.* **2009**, *35*, 1304–1311. [CrossRef]
15. Fan, D.; Breslin, D.; Callahan, J.L.; Iszatt-White, M. Advancing literature review methodology through rigour, generativity, scope and transparency. *Int. J. Manag. Rev.* **2022**, *24*, 171–180. [CrossRef]
16. Hoon, C. Meta-Synthesis of Qualitative Case Studies: An Approach to Theory Building. *Organ. Res. Methods* **2013**, *16*, 522–556. [CrossRef]
17. Kunisch, S.; Menz, M.; Bartunek, J.M.; Cardinal, L.B.; Denyer, D. Feature Topic at Organizational Research Methods: How to Conduct Rigorous and Impactful Literature Reviews? *Organ. Res. Methods* **2018**, *21*, 519–523. [CrossRef]
18. Rynes, S.L.; Bartunek, J.M. Evidence-based management: Foundations, develop-ment, controversies and future. *Annu. Rev. Organ. Psychol. Organ. Behav.* **2017**, *4*, 235–261. [CrossRef]
19. Antons, D.; Breidbach, C.F. Big Data, Big Insights? Advancing Service Innovation and Design With Machine Learning. *J. Serv. Res.* **2018**, *21*, 17–39. [CrossRef]
20. Borman, G.D.; Maritza Dowling, N. Teacher attrition and retention: A meta-analytic and narrative review of the research. *Rev. Educ. Res.* **2008**, *78*, 367–409. [CrossRef]
21. Carrillat, F.A.; Legoux, R.; Hadida, A.L. Debates and assumptions about motion picture performance: A meta-analysis. *J. Acad. Mark. Sci.* **2018**, *46*, 273–299. [CrossRef]
22. Snyder, H. Literature review as a research methodology: An overview and guidelines. *J. Bus. Res.* **2019**, *104*, 333–339. [CrossRef]

23. Ford, J.D.; Pearce, T. What we know, do not know, and need to know about climate change vulnerability in the western Canadian Arctic: A systematic literature review. *Environ. Res. Lett.* **2010**, *5*, 014008. [CrossRef]
24. Naseri, M.; Malekzadeh, R. "Systematic Review": Is It Different from the "Traditional Review". *Arch. Iran. Med.* **2006**, *9*, 196–199. Available online: https://www.sid.ir/en/Journal/ViewPaper.aspx?ID=44192 (accessed on 18 August 2022).
25. Nehler, T. A Systematic Literature Review of Methods for Improved Utilisation of the Non-Energy Benefits of Industrial Energy Efficiency. *Energies* **2018**, *11*, 3241. [CrossRef]
26. Dantas, T.E.T.; Soares, S.R. Systematic literature review on the application of life cycle sustainability assessment in the energy sector. *Environ. Dev. Sustain.* **2021**, *24*, 1583–1615. [CrossRef]
27. Reichert, B.; Souza, A.M. Can the Heston Model Forecast Energy Generation? A Systematic Literature Review. *Int. J. Energy Econ. Policy* **2022**, *12*, 289–295. [CrossRef]
28. Bhattarai, B.P.; Paudyal, S.; Luo, Y.; Mohanpurkar, M.; Cheung, K.; Tonkoski, R.; Hovsapian, R.; Myers, K.S.; Zhang, R.; Zhao, P.; et al. Big data analytics in smart grids: State-of-theart, challenges, opportunities, and future directions. *IET Smart Grid* **2019**, *2*, 141–154. [CrossRef]
29. Khosrojerdi, F.; Akhigbe, O.; Gagnon, S.; Ramirez, A.; Richards, G. Integrating artificial intelligence and analytics in smart grids: A systematic literature review. *Int. J. Energy Sect. Manag.* **2022**, *16*, 318–338. [CrossRef]
30. Leal Filho, W.; Yang, P.; Eustachio, J.H.P.P.; Azul, A.M.; Gellers, J.C.; Gielczyk, A.; Dinis, M.A.P.; Kozlova, V. Deploying digitalisation and artificial intelligence in sustainable development research. *Environ. Dev. Sustain.* **2022**. [CrossRef]
31. Suharto, D.G.; Tando, C.E. Investment policy and environmental conservation: A systematic literature review on the form of investment policy and stakeholders role. *IOP Conf. Ser. Earth Environ. Sci.* **2021**, *905*, 012112. [CrossRef]
32. Bardazzi, E.; Bosello, F. Critical reflections on Water-Energy-Food Nexus in Computable General Equilibrium models: A systematic literature review. *Environ. Model. Softw.* **2021**, *145*, 105201. [CrossRef]
33. Boloy, R.A.M.; da Cunha Reis, A.; Rios, E.M.; de Araújo Santos Martins, J.; Soares, L.O.; de Sá Machado, V.A.; de Moraes, D.R. Waste-to-Energy Technologies Towards Circular Economy: A Systematic Literature Review and Bibliometric Analysis. *Water Air Soil Pollut.* **2021**, *232*, 306. [CrossRef]
34. Solman, H.; Smits, M.; van Vliet, B.; Bush, S. Co-production in the wind energy sector: A systematic literature review of public engagement beyond invited stakeholder participation. *Energy Res. Soc. Sci.* **2021**, *72*, 101876. [CrossRef]
35. Cader, J.; Koneczna, R.; Smol, M. Corporate social responsibility as a significant factor of competitive advantage—A case study of energy companies in Poland. *Energy Rep.* **2022**, *8*, 7989–8001. [CrossRef]
36. Borges, F.M.M.G.; Rampasso, I.S.; Quelhas, O.L.G.; Leal Filho, W.; Anholon, R. Addressing the UN SDGs in sustainability reports: An analysis of Latin American oil and gas companies. *Environ. Chall.* **2022**, *7*, 100515. [CrossRef]
37. Cortez, M.C.; Andrade, N.; Silva, F. The environmental and financial performance of green energy investments. *Eur. Evid. Ecol. Econ.* **2022**, *197*, 107427. [CrossRef]
38. Hariyani, D.; Mishra, S. Drivers for the adoption of integrated sustainable green lean six sigma agile manufacturing system (ISGLSAMS) and research directions. *Clean. Eng. Technol.* **2022**, *7*, 100449. [CrossRef]
39. ur Rehman, O.; Ali, Y.; Sabir, M. Risk assessment and mitigation for electric power sectors: A developing country's perspective. *Int. J. Crit. Infrastruct. Prot.* **2022**, *36*, 100507. [CrossRef]
40. Bourcet, C. Empirical determinants of renewable energy deployment: A systematic literature review. *Energy Econ.* **2020**, *85*, 104563. [CrossRef]
41. Dogan, E.; Inglesi-Lotz, R.; Altinoz, B. Examining the determinants of renewable energy deployment: Does the choice of indicator matter? *Int. J. Energy Res.* **2021**, *45*, 8780–8793. [CrossRef]
42. Fonseca, J.D.; Camargo, M.; Commenge, J.M.; Falk, L.; Gil, I.D. Trends in design of distributed energy systems using hydrogen as energy vector: A systematic literature review. *Int. J. Hydrogen Energy* **2019**, *44*, 9486–9504. [CrossRef]
43. Lerro, A.; Schiuma, G.; Jacobone, F.A. Knowledge assets management in the energy industry: A systematic literature review. *Knowl. Manag. Compet. Advant. Dur. Econ. Crisis* **2014**, 38–55. [CrossRef]
44. Naseer, M.N.; Zaidi, A.A.; Dutta, K.; Wahab, Y.A.; Jaafar, J.; Nusrat, R.; Ullah, I.; Kim, B. Past, present and future of materials' applications for CO_2 capture: A bibliometric analysis. *Energy Rep.* **2022**, *8*, 4252–4264. [CrossRef]
45. Ante, L.; Steinmetz, F.; Fiedler, I. Blockchain and energy: A bibliometric analysis and review. *Renew. Sustain. Energy Rev.* **2021**, *137*, 110597. [CrossRef]
46. Mindeli, L.E.; Akoev, M.A.; Zolotova, A.V.; Libkind, A.N.; Markusova, V.A. Bibliometric Evaluation of Development Trends in Domestic Research and Models of Scientific Cooperation in Basic Energy Science. *Her. Russ. Acad. Sci.* **2020**, *90*, 476–486. [CrossRef]
47. Mahi, M.; Mobin, M.A.; Habib, M.; Akter, S. A bibliometric analysis of pandemic and epidemic studies in economics: Future agenda for COVID-19 research. *Soc. Sci. Humanit. Open* **2021**, *4*, 100165. [CrossRef]
48. Pinilla-De La Cruz, G.A.; Rabetino, R.; Kantola, J. Public-Private Partnerships (PPPs) in Energy: Identifying the Key Dimensions from Two Different Bibliometric Analyzes. In *International Conference on Applied Human Factors and Ergonomics*; Springer: Cham, Switzerland, 2020; pp. 65–71. [CrossRef]
49. Menéndez-Manjón, A.; Moldenhauer, K.; Wagener, P.; Barcikowski, S. Nano-energy research trends: Bibliometrical analysis of nanotechnology research in the energy sector. *J. Nanoparticle Res.* **2011**, *13*, 3911–3922. [CrossRef]

50. Araújo, D.F.A.; Costa, A.P.C.S. Bibliometric Analysis of RD in the Energy Sector. *IEEE Lat. Am. Trans.* **2016**, *14*, 1221–1226. [CrossRef]
51. Khirfan, L.; Peck, M.; Mohtat, N. Systematic content analysis: A combined method to analyze the literature on the daylighting (de-culverting) of urban streams. *MethodsX* **2020**, *7*, 100984. [CrossRef]
52. Forman, J.; Damschroder, L. Qualitative Content Analysis. *Adv. Bioeth.* **2007**, *11*, 39–62. [CrossRef]
53. Neuendorf, K.A. *The Content Analysis Guidebook*, 2nd ed.; Sage: Thousand Oaks, CA, USA, 2017.
54. Cherepovitsyn, A.; Solovyova, V. Prospects for the Development of the Russian Rare-Earth Metal Industry in View of the Global Energy Transition—A Review. *Energies* **2022**, *15*, 387. [CrossRef]
55. Carayannis, E.G.; Ilinova, A.; Cherepovitsyn, A. The Future of Energy and the Case of the Arctic Offshore: The Role of Strategic Management. *J. Mar. Sci. Eng.* **2021**, *9*, 134. [CrossRef]
56. Pranindita, N.; Sagala, S.; Samosir, A.; Anhorn, J.; van Laere, A.K.; Zacepins, A.; Sainz, A.; Rutz, D.; Rosslee, D.; Kirchmeyr, F.; et al. Biogas Market in Indonesia: The Roles of Carbon Trading. In Proceedings of the 2021 3rd International Sustainability and Resilience Conference: Climate Change, Online, 15–16 November 2021; pp. 199–204. [CrossRef]
57. Matseke, D.A.; Khatleli, N. Claims management: Underlying causes in mega-construction projects. *Proc. Int. Struct. Eng. Constr.* **2021**, *8*, CON-27-1–CON-27-6. [CrossRef]
58. Ahmadzai, S.; McKinna, A. Afghanistan electrical energy and trans-boundary water systems analyses: Challenges and opportunities. *Energy Rep.* **2018**, *4*, 435–469. [CrossRef]
59. Skjott Linneberg, M.; Korsgaard, S. Coding qualitative data: A synthesis guiding the novice. *Qual. Res. J.* **2019**, *19*, 259–270. [CrossRef]
60. Milani, F. *Digital Business Analysis*; Springer International Publishing: Basel, Switzerland, 2019; pp. 1–429. [CrossRef]
61. Kataev, M.; Bulysheva, L. A novel model of efficiency of the enterprise planning with process-oriented approach to management. In Proceedings of the 2014 Enterprise Systems Conference, Shanghai, China, 2–3 August 2014; pp. 108–111. [CrossRef]
62. Cowan, K.R.; Daim, T.U. Review of technology acquisition and adoption research in the energy sector. *Technol. Soc.* **2011**, *33*, 183–199. [CrossRef]
63. Latapí Agudelo, M.A.; Johannsdottir, L.; Davidsdottir, B. Drivers that motivate energy companies to be responsible. A systematic literature review of Corporate Social Responsibility in the energy sector. *J. Clean. Prod.* **2020**, *247*, 119094. [CrossRef]
64. Kurka, T.; Blackwood, D. Participatory selection of sustainability criteria and indicators for bioenergy developments. *Renew. Sustain. Energy Rev.* **2013**, *24*, 92–102. [CrossRef]
65. Sukiennik, M.; Bąk, P. Corporate culture versus CSR in Polish companies of the energy sector. *IOP Conf. Ser. Earth Environ. Sci.* **2019**, *214*, 012075. [CrossRef]
66. Lis, A.; Rybkowski, R. Linkages between Academic Culture and Management in Polish Higher Education. In *Sustaining the Future of Higher Education*; Broucker, B., Pritchard, R.M.O., Melin, G., Milsom, C., Eds.; Brill: Leiden, The Netherlands, 2021; pp. 136–152. [CrossRef]
67. Mariz, F.B.A.R.; Almeida, M.R.; Aloise, D. A review of Dynamic Data Envelopment Analysis: State of the art and applications. *Int. Trans. Oper. Res.* **2018**, *25*, 469–505. [CrossRef]
68. Serban, A.C.; Lytras, M.D. Artificial intelligence for smart renewable energy sector in Europe—Smart energy infrastructures for next generation smart cities. *IEEE Access* **2020**, *8*, 77364–77377. [CrossRef]
69. Amer, M.; Daim, T.U. Application of technology roadmaps for renewable energy sector. *Technol. Forecast. Soc. Change* **2010**, *77*, 1355–1370. [CrossRef]
70. Strengers, Y. Peak electricity demand and social practice theories: Reframing the role of change agents in the energy sector. *Energy Policy* **2012**, *44*, 226–234. [CrossRef]
71. Kuckartz, U.; Rädiker, S. Analyzing Focus Group Data. In *Analyzing Qualitative Data with MAXQDA*; Springer International Publishing: Basel, Switzerland, 2019; pp. 201–217. [CrossRef]
72. Brutschin, E.; Fleig, A. Innovation in the energy sector—The role of fossil fuels and developing economies. *Energy Policy* **2016**, *97*, 27–38. [CrossRef]
73. He, J.; Deng, J.; Su, M. CO_2 emission from China's energy sector and strategy for its control. *Energy* **2010**, *35*, 4494–4498. [CrossRef]
74. Bracco, S.; Delfino, F.; Pampararo, F.; Robba, M.; Rossi, M. The University of Genoa smart polygeneration microgrid test-bed facility: The overall system, the technologies and the research challenges. *Renew. Sustain. Energy Rev.* **2013**, *18*, 442–459. [CrossRef]