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A comprehensive bibliometric analysis of applying Q-methodology in the energy sector. A valuable tool in energy transition pathways

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Highlights:

- First bibliometric analysis of Q-methodology in energy research.
- Maps key trends in stakeholder engagement and renewable energy transition studies.
- Unveils global research networks and thematic shifts in Q-methodology applications.
- Highlights Q-methodology's role in studying wind, solar bioenergy and hydropower.

Abstract: This study uses Scopus and Web of Science data to offer a bibliometric analysis of Q-methodology applications in the energy sector with a particular focus on renewable energy research. Seventy-six publications (2007–2024) were analyzed using Bibliometrix and VOSviewer tools, uncovering the field's intellectual and conceptual structure. The research identifies key contributors, such as Delft University of Technology, and leading journals, including Energy Policy and Energy Research & Social Science. The findings reveal thematic shifts in Q-methodology applications over time. Early studies emphasized stakeholder engagement and public acceptance, particularly in relation to wind energy and bioenergy. More recent works address region-specific studies on solar PV, hydropower, and participatory governance in developing countries. Bibliometric coupling and keyword co-occurrence analysis highlight key themes like renewable energy adoption, participatory methods in energy projects, and energy justice. Collaboration networks demonstrate strong international ties, particularly between European and North American institutions. This analysis fills a gap in the literature by systematically mapping the bibliometric landscape of Q-methodology in renewable energy research. The findings offer a foundation for future studies and contribute to a deeper understanding of how Q-methodology can support inclusive and sustainable renewable energy transitions.

Keywords: Q-methodology; stakeholder perspectives; bibliometric analysis; renewable energy transition

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1. Introduction

The world faces unprecedented climate change directly related to increased greenhouse gas (GHG) concentrations caused by human activities. This concern has led international forums, such as "Climate Summits" to propose an energy transition process in which clean energy will replace fossil fuels. Achieving these goals implies a challenging technical pathway but also the design of an energy governance model capable of ensuring a fair and inclusive energy transition. Governance refers to the process by which societies make collective decisions and establish institutions that guide behavior Traditional centralized and hierarchical governance models have shown limited effectiveness in fostering sustainable energy transitions [1,2]. In contrast, a growing body of research advocates for participatory governance frameworks that take into account the perceptions, values, and priorities of multiple stakeholders [3].

Understanding the plurality of stakeholders involved in energy transitions is essential for the design of inclusive and effective policies, several methods have been employed to elicit such views, including interviews, focal groups and Q-Methodology. Among these, Q-Methodology offers a unique mixed-methods approach that combines qualitative depth with quantitative structure, mapping subjective viewpoints on complex issues [4]. This technique allows researchers to identify shared perspectives by having participants rank and sort statements according to their degree of agreement or disagreement [5], and then uses factor analysis to cluster these responses into typologies of discourse [6].

Q-method is especially appropriate for exploring contested social debates and uncovering patterns of consensus and conflict within a small, strategically selected participant group. Its use has expanded across diverse fields such as sociology [6], healthcare [7], education [8], political sciences [9] and, psychology [10], and increasingly, energy and transportation studies [11].

Q-methodology has proven especially valuable in the context of renewable energy, where social acceptance, legitimacy, and stakeholder alignment are often as critical as technological feasibility. It has been widely used to explore conflicts over wind farms, perceptions of hydropower, stakeholder positions on solar development, and broader governance challenges in decarbonization pathways.

What makes Q-method particularly valuable in energy-related research is its ability to uncover deep-seated perceptions, conflicts, and alignments among stakeholders—issues that often determine the success or failure of renewable energy projects. For example, it has been used to reveal tensions surrounding wind energy developments in rural communities, divergent stakeholder narratives about hydropower's environmental impacts, and contrasting views on fairness and justice in the deployment of solar PV or bioenergy infrastructure. These applications highlight the method's unique capacity to address not just what people think, but why they think it—providing crucial insights for participatory governance, conflict resolution, and socially responsive energy planning.

The study's main objective is to perform a comprehensive bibliometric analysis of the literature on Q-methodology as applied in the energy sector. This paper specifically seeks to examine the academic realm of Q-methodology within the energy sector, emphasizing its role in elucidating renewable energy systems' social and political aspects. The defined objectives are: SO1. To uncover significant academic interests and publication trends related to Q-methodology in energy research, emphasizing its application in studies focused on renewable energy technologies and transition processes. SO2. To identify the key thematic areas and research topics investigated via Q-method, focusing on cases related to wind energy,

solar PV, bioenergy, and hydropower, aiming to uncover common challenges concerning social acceptance, stakeholder engagement, and energy justice. SO3. To map collaboration networks among authors, countries, and institutions, revealing the global research architecture that supports Q-method applications in the context of participatory renewable energy governance.

The study evaluates published works to track the development and evolution of Q-methodology in the energy field since the beginning of the 21st century, establishing the role of this methodology in designing successful energy transition strategies. The dataset, sourced from the Web of Science and Scopus databases, was processed using the Bibliometrix R package in RStudio and VOSviewer software. Seventy-six articles were analyzed to uncover patterns and trends in research on the concept. As big data technology and artificial intelligence continue to advance, bibliometric analysis methods are evolving significantly, broadening their scope of application and the depth of their insights. Although various bibliometric studies have been conducted in the energy domain [12–17], to the best of our knowledge, no prior studies have specifically analyzed the bibliometric landscape of Q-methodology within the energy sector.

This research fills a critical gap in the literature by providing the first comprehensive bibliometric overview of Q-methodology in the energy sector. Its findings serve as a valuable resource for future studies, offering insights into the historical trajectory and the field's current state. By aligning its analysis with the societal and academic priorities of energy transitions, this study provides a robust framework for researchers and policymakers to harness Q-methodology to navigate the complexities of global energy challenges. This task contributes to future energy policies and projects to be more inclusive, stakeholder-driven, and socially sustainable.

While this study does not aim to conduct a systematic review of findings, it offers a critical mapping of how Q-methodology has been applied to investigate key challenges in the renewable energy transition. In particular, it highlights the method's contributions to three interrelated domains: (1) public acceptance and energy justice, (2) policy design and governance, and (3) participatory stakeholder dialogue. These thematic dimensions guide the structure of our analysis and reflect the evolving role of Q-method in shaping inclusive and context-sensitive energy systems.

The structure of this work is as follows. Section 2 details the data sources (Scopus and Web of Science), the search and selection criteria, and the analytical strategies used for the bibliometric analysis. Next, the results section presents the evaluative and relational bibliometric techniques applied, including productivity measures, impact metrics, bibliographic coupling, and keyword co-occurrence analysis. These results identify key research themes, academic sources, and emerging trends in applying Q-methodology to renewable energy studies. Finally, the Conclusion synthesizes the most relevant insights, emphasizing the study's contribution to understanding the intellectual and conceptual structure of this field, and proposes future research directions in socially inclusive energy transition research.

2. Methods

In this section, we present the data sources, the search and collection of studies on the Q-Method in energy literature, and the strategies followed to produce a bibliometric analysis on the subject. Bibliometrics is an academic science that aims to evaluate the research developed by any scientific community in any field [18]. Specifically, Bibliometrics is the study of academic publishing that uses statistics to describe publishing trends and to highlight relationships between published works [19]. We

applied various bibliometric techniques, either evaluative to describe the characteristics of published information and its impact (productivity measures and impact metrics) or relational that explore relationships within research (structure of research fields, emergence of new research themes, co-citation, co-authorship, keyword co-occurrence, *etc.*) [19]. The analysis aims to access the intellectual structure of the field, "who produces knowledge," and the conceptual structure of the field, "what is being researched."

In the present research, we applied a recommended workflow for conducting science mapping studies with bibliometric methods as defined by [20], Figure 1. After the Study Design stage where objectives were formulated, the next stage is Data collection, which involves selecting the databases containing bibliometric data and choosing the documents by applying filtering criteria. Web of Science and Scopus databases are fundamental for conducting bibliometric analysis due to their broad coverage and diversity of peer-reviewed scientific articles globally [14]. These databases provide access to high-quality publications, ensuring the relevance and academic rigor of the studies selected for review. Moreover, their advanced search functionalities—allowing searches by title, abstract, and keywords—contribute to an accurate and comprehensive collection of relevant literature on the study topic.

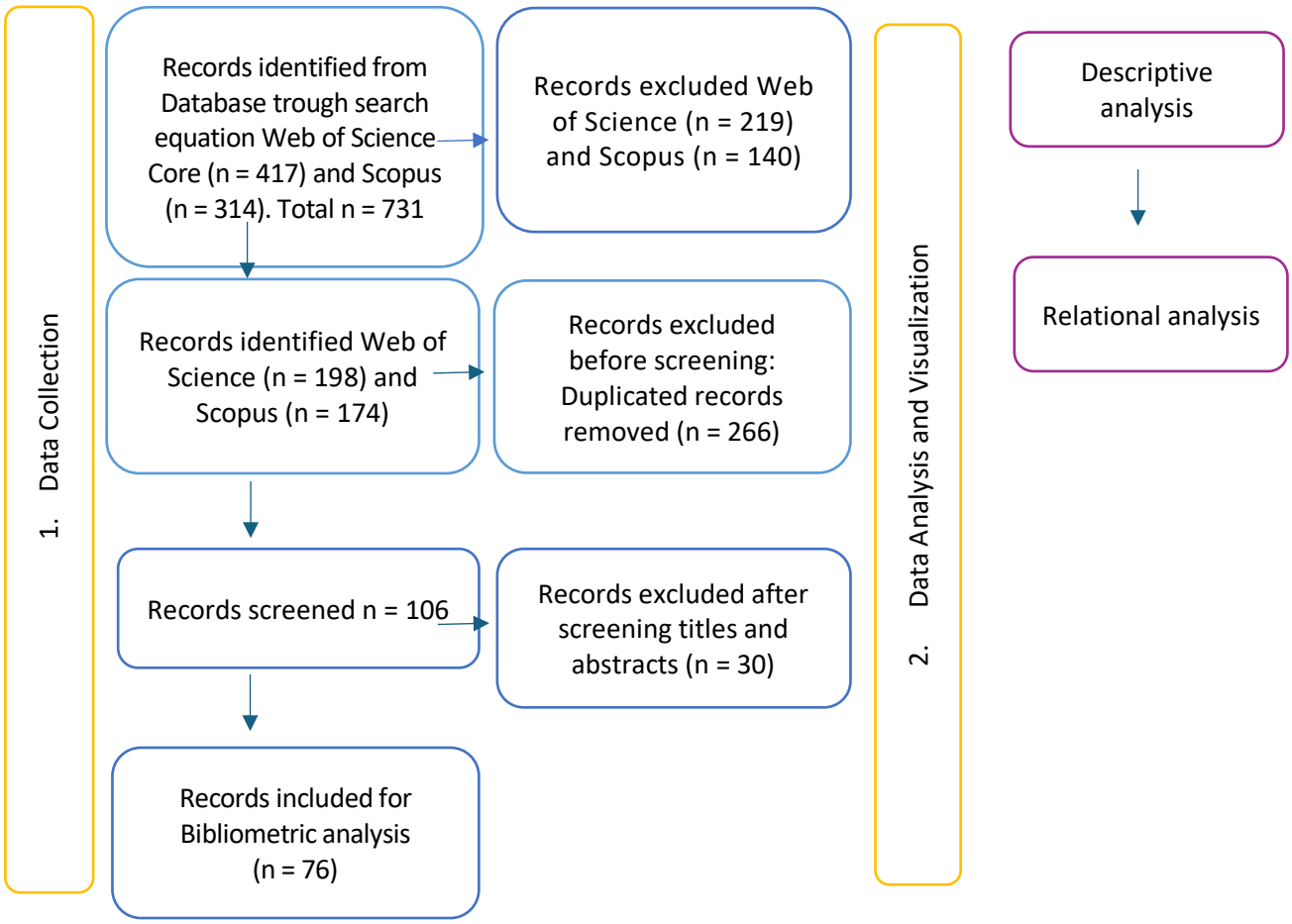


Figure 1. Bibliometric analysis workflow chart. Source: Own elaboration based in Zupic & Čater (2015) [20].

A preliminary assessment of the literature on energy and the Q-methodology is conducted, and appropriate keywords related to the objectives of the work are identified to select the most relevant articles. The scope of the bibliometric analysis covers articles that apply the Q method in the energy sector, and

therefore, fundamental keywords related to energy and the Q method are selected, separated into two groups: Group 1 contains the keyword "Energy," and Group 2 includes the keywords "Q Method." After selecting keywords, the logical relationships between them are determined using one canonical search equation formulated through Boolean logical operators that appropriately combine them. In our case, the equation should contain Group 1 and Group 2 terms and, therefore, will be written as "Energy" AND "Q Method." Additionally, it may be necessary to include synonyms to improve the search (Q Technique or Q Study), which can also be written as Q-methodology, Q-technique, and Q-study. To synonyms within a group, the equation will include the OR Boolean. It is common to use wildcard characters (*) to define families of terms with the same root and different endings (Table 1).

Defining the inclusion/exclusion criteria for primary sources is essential as part of the Data Collection stage. The selection of publications follows three criteria. First, only studies within the specified WoS categories and Scopus subject areas are included, excluding those referring to unrelated "Q" processes in fields like physics or engineering. Second, only publications from the 21st century onward are considered. Third, documents must be in English due to its predominance in bibliometric studies (Table 1).

The database search identifies 731 records to which the inclusion/exclusion criteria are applied. From the Web of Science and Scopus databases, 359 records are excluded, 13 for not being written in English and 346 for not belonging to the selected WoS Categories. As a result, the study identifies 198 records from Web of Science and 174 from Scopus. The retrieved records are imported into RStudio, which removes 266 duplicates and merges the remaining 106 records into a single file. The research team screened the publications using Excel by reading the "Titles" and "Abstracts" and agreed to exclude those publications where applying the Q-methodology to energy is not the primary objective. In reality, the works are applications of the Q-methodology but are focused on other aspects, such as environmental issues. Therefore, 30 records are excluded from the database, resulting in 76 selected documents.

Table 1. Bibliometric data collection.

Data Sources	**Databases Web of Science and Scopus**
Publication type	Article Review, Book chapter, Proceeding peer reviewed
Inclusion/exclusion criteria	(1) Wos categories for Web of Science[a] Subject Area for Scopus[b] (2) Timeframe 2000–may 2024 (3) English language
Search Terms Web of Science: All Fields Scopus. Article Title, Abstract, Keywords	Group 1: "Energ*" Group 2: "Q method*" "Q-method*" "Q-techni*" "Q techni*" "Q-stud*" "Q stud*"
Search Strategy	AND between groups 1, 2. OR within group 2
Canonical search equation	"Energ*" AND ("Q method*" OR "Q-method*" OR "Q-techni*" OR "Q techni*" OR "Q-stud*" OR "Q stud*")

[a]. Wos Categories: Development Studies, Economics, Energy & Fuels, Environmental Sciences, Environmental Studies, Geography, Green & Sustainable Science & Technology, History & Philosophy of Science; Interdisciplinary, Interdisciplinary Applications, Management Science, Political Science, Public Administration, Regional & Urban Planning, Social Sciences, Water resources.

[b]. Subject areas Scopus: Business, Management and Accounting, Decision Sciences, Economics, Econometrics and Finance, Energy, Environmental Science, Multidisciplinary, Social Sciences.

The next stage is Data Analysis, which implies descriptive analysis of a bibliographic data frame and network extraction, processed in the Bibliometrix package in R designed by [21]. Different networks or maps of a research field can be extracted using various units of analysis. If the unit of study consists of keywords or terms extracted from the title, abstract, or document's body, a semantic map of a field can be created to understand its cognitive structure. A map of the social structure and collaboration networks can be generated if the chosen unit is the author and their affiliation. If citations are used as the unit of analysis, networks of similarity between documents, authors, and journals can be identified.

We will divide the analysis into two parts to respond to the objectives of the work. The first will be descriptive, covering the trend in the number of publications, author productivity, sources, countries, and institutions, the impact of the publications, and finally, the analysis of the keywords in the documents (SO1). The second part is relational and is twofold, the first examining the bibliographic coupling of publications. This will delve deeper by identifying specific topics through the frequency and co-occurrence of keywords (SO2). Second, it explores collaborations between authors, countries, and institutions (SO3). Finally, any previously mentioned bibliometric networks can be graphically visualized during the Data Visualization stage, for which we use the VOSviewer software [22].

3. Results

This section addresses the study's primary objective, which is to conduct the bibliometric analysis of the 76 selected publications to study the main characteristics of these publications and the trends followed in recent years.

3.1. Descriptive analysis

This subsection will be descriptive, covering the first specific objective (SO1), considering trends in the number of publications, authors, journals, countries, institutions, citations, and keywords.

3.1.1. Main information and publication trends

Bibliometrix produces a summary sheet containing the key metrics presented in Table 2. It detailed 76 publications from 47 different sources between 2007 and 2024. 210 authors contributed to these publications, with an average of 3.2 authors per document. Notably, 86% of these works are multi-authored, while only 10 publications have one author. The average number of citations per publication per year is 3.29. Most of these publications are articles (n = 72).

Figure 2 initially illustrates the annual number of articles published concerning the Q-methodology in energy (in purple). It is noteworthy to emphasize a significant surge in the volume of published articles, reaching a peak in 2019, followed by a considerable decline in 2020 and a subsequent period of stabilization. Furthermore, Figure 2 presents the average citations garnered by articles published each year (in red). Notable volatility is observed in the years 2007 and 2010, during which a limited number of articles were published but received a substantial number of citations. This observation suggests that these articles may be considered seminal within their respective field. Additionally, this figure also provides (in green) an estimate of the total citations accrued by all articles each year throughout the analyzed period, calculated based on average values. The total number of citations has consistently escalated over the period in question, with a more pronounced increase commencing in 2014 and certain

stagnation in recent years. It is important to note that 2024, while illustrated in the figure, represents an incomplete year at the time the data was collected, resulting in abnormally low publication and citation figures for that year. These three findings lead us to conclude that the Q-methodology is a subject of increasing interest, indicating its potential applicability as a tool for examining the implementation of the energy transition across various countries.

Table 2. Main information about the data.

Timespan	**2007: 2024**
Sources (Journals, Books, *etc.*)	47
Number of documents and types	76 72 articles 2 book chapters 1 conference papers 1 proceeding paper
Annual Growth Rate %	6, 68
Document Average Age	6, 01
Average citations per document	23, 43
References	4050
Documents contents	266 Keywords Plus (ID) 272 Author's Keywords (DE)
Authors	210 authors 10 authors of single-authored docs
Authors collaboration	10 Single-authored docs 3, 22 Co-Authors per Doc 22.37% International co-authorships

Source: Main information Table. R results.

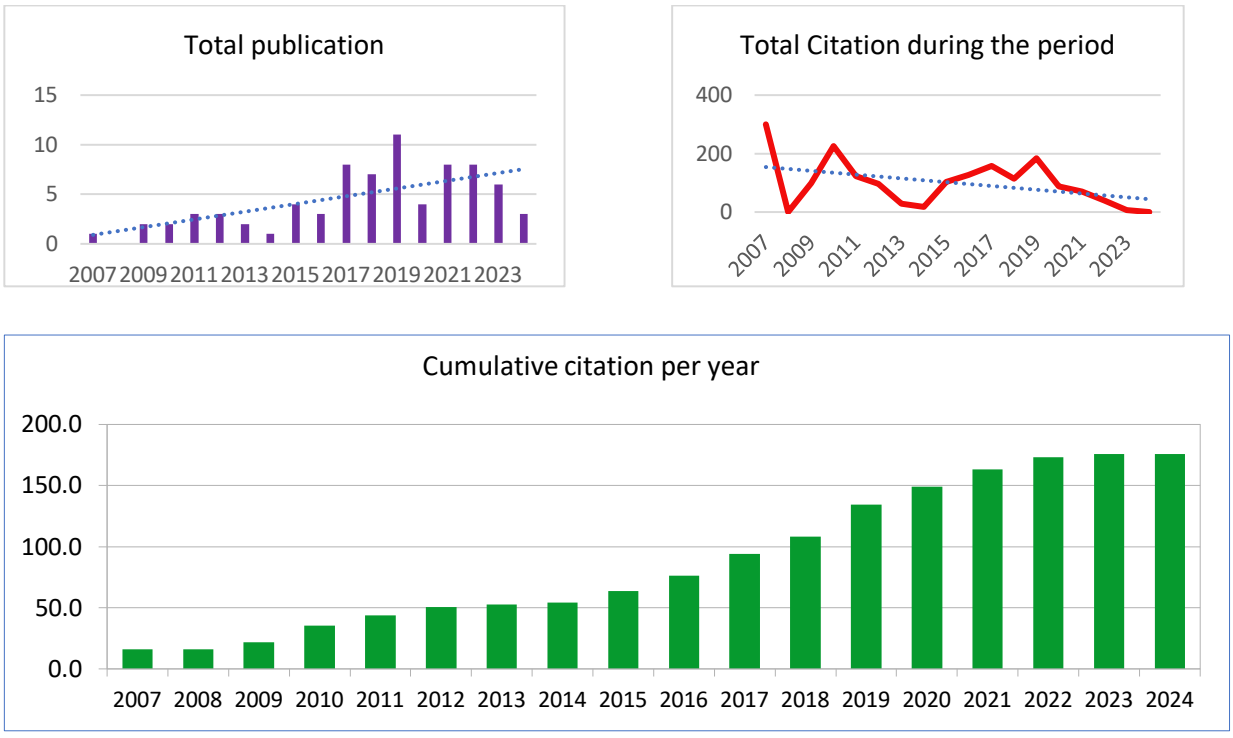


Figure 2. Evolution of the production and citations of literature on applications of the Q method in energy. Source: Own elaboration based in R results.

3.1.2. Productivity of authors and sources

Table 3 presents the top 10 authors and sources ranked by number of publications and shows their H-index, G-index, M-index, and total citations. The H-index measures an author's productivity and impact based on their citations. An author with an H-index of 7, like Cuppen, E., has seven papers that have each been cited at least 7 times. This index combines the number of publications and their citation impact [23], highlighting that Cuppen, E. significantly influences the field with 367 total citations across seven publications. However, authors like Ellis, G. do not demonstrate a high impact as he has only a single, albeit highly cited, work. The G-index gives more weight to highly cited papers, meaning it considers the top publications with significant citation impact [23]. For example, Cuppen, E. and Brannstrom, C. have G-indexes of 7 and 5, respectively, reflecting their ability to produce work that garners many citations. This metric favors researchers whose top publications are highly influential. Conversely, the M-index adjusts the H-index to the years since the researcher's first publication [24]. This index highlights the pace of impactful publishing, with Venus T. having the highest M-index (0.600), indicating that their impactful work has occurred over a shorter period.

Regarding journal performance, Table 3, Energy Policy leads with 13 publications, an H-index of 12, and a G-index of 13, reflecting its articles' productivity and high impact. This journal also has the highest total citations (325), showcasing its dominance in energy research. Another influential journal, Energy Research & Social Science has 6 publications with 77 citations. Environment and Planning A-Economy and Space has achieved 152 citations with just 4 publications, emphasizing quality over quantity.

Table 3. Top 10 authors and sources with impact. H-index, G-index, M-index.

Authors	H	G	M	Citation	Articles	Sources	H	G	M	Citation	Articles
CUPPEN E	7	7	0, 46	367	7	ENERGY POLICY	12	13	1	325	13
BRANNSTROM C	4	5	0, 28	186	5	ENERGY RESEARCH & SOCIAL SCIENCE	4	6	0, 57	77	6
VENUS T	3	3	0, 60	45	3	ENVIRONMENT AND PLANNING A-ECONOMY AND SPACE	4	4	0, 25	152	4
FRATE C	3	3	0, 37	64	3	SUSTAINABILITY	2	3	0, 33	16	3
COTTON M	3	3	0, 21	110	3	FUTURES	2	3	0, 22	64	3
ULLAH K	2	3	0, 25	51	3	ENVIRONMENTAL INNOVATION AND SOCIETAL TRANSITIONS	2	2	0, 4	41	2
DIAZ P	2	2	0, 25	57	2	JOURNAL OF ENVIRONMENTAL POLICY \& PLANNING	2	2	0, 33	11	2
KILPELAINEN S	2	2	0, 25	20	2	JOURNAL OF ENVIRONMENTAL PLANNING AND MANAGEMENT	2	2	0, 11	365	2
AALTO P	2	2	0, 25	20	2	ENERGIES	1	2	0, 16	4	2
MEHOS D	2	2	0, 22	121	2	ECOLOGICAL ECONOMICS	1	2	0, 06	160	2

Source: Own elaboration based on R results.

3.1.3. Productivity of countries and affiliations

Figure 3a illustrates the productivity of corresponding authors from various countries from 2000 to 2024. The United Kingdom leads significantly with the highest productivity level, close to 16 documents, followed by the Netherlands. The difference between these two and the rest is so pronounced that they account for the majority of the total value. United States, China, Spain Pakistan and Germany demonstrate moderate productivity levels, while Finland, Korea, Austria and Sweden show slightly lower contributions. Countries like Hungary, Italy, and Poland between others, have the lowest productivity among the listed countries.

Figure 3b focuses on the top 10 universities and research institutions involved in our research topic. Delft University of Technology leads with 9 publications, reflecting its prominent role in the field. Texas A&M University System follows with 5 publications, while the University of Cambridge has 4. Other notable contributors include the University of Leeds, National University of Sciences & Technology, Universidade de Brasilia, Swiss Federal Institute of Technology, and ETH Zurich, each contributing 3 publications. Leading institutions represent a combination of European and North American universities.

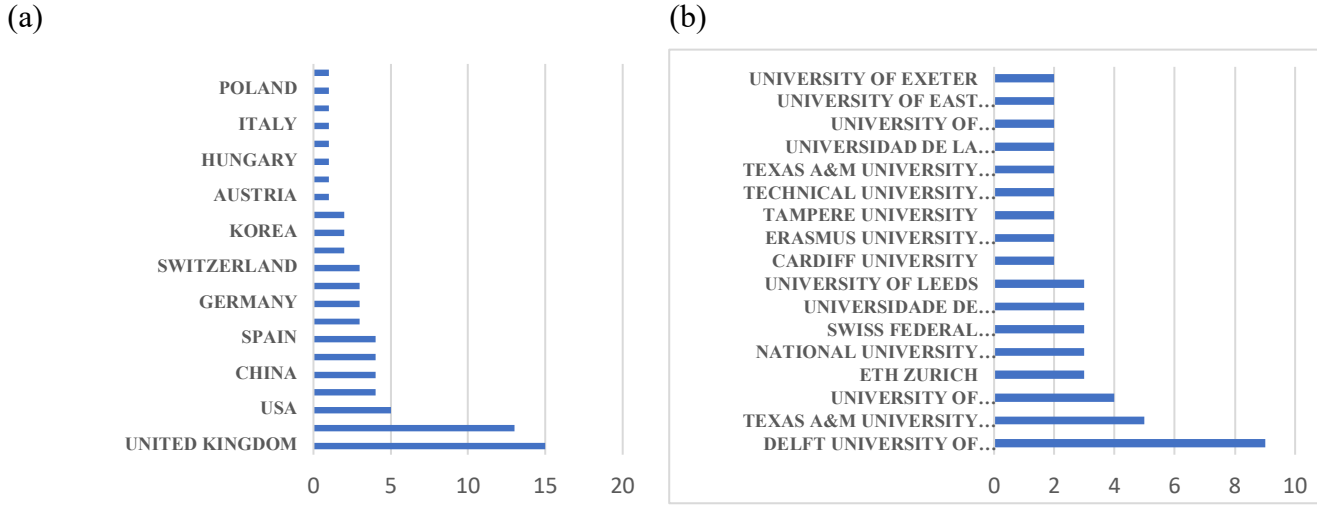


Figure 3. Productivity of the countries and Affiliations 2000–2024. **(a)** Number of publications of the corresponding author; **(b)** Number of articles with at least one author/institution. Source: Own elaboration based on R results.

3.1.4. Impact of publications

Table 4 showcases the ten most cited publications that employ Q-methodology in energy research. A distinct pattern arises: the leading studies emphasize stakeholder perspectives and socio-political factors concerning the implementation of renewable energy. Thus, it includes public acceptance, stakeholder engagement, and conflict resolution in wind energy, bioenergy, and hydropower projects.The most frequently cited article, "Many Ways To Say 'No,' Different Ways To Say 'Yes'" of Ellis, Barry and Robinson [25], has garnered 300 citations and examines both public opposition and support for wind farms in Northern Ireland. Other notable works with high citation counts include Cuppen *et al.* (2010) [26], which focuses on biomass, Wolsink and Breukers (2010) [27] addressing stakeholder engagement in wind energy, and Diaz *et al.* (2017) [28], which discusses governance in hydropower. These studies illustrate

how Q-methodology has uncovered differing narratives, issues of institutional trust, and perceptions of procedural and distributive justice within renewable energy.

Although there are fewer studies on non-renewable technologies like nuclear energy and shale gas, the main emphasis remains squarely on renewable energy systems and their social and environmental impacts. This highlights the strategic importance of Q-methodology in exploring stakeholder diversity and guiding participatory methods for equitable and inclusive energy transitions.

Table 4. Top 10 most cited publications.

Rank	Title	Total citations	Authors	Publication Year
1	Many Ways To Say 'No', Different Ways To Say 'Yes': Applying Q-Methodology To Understand Public Acceptance Of Wind Farm Proposals	300	Ellis, G.; Barry, J.; Robinson, C.	2007
2	Q Methodology To Select Participants For A Stakeholder Dialogue On Energy Options From Biomass In The Netherlands	160	Cuppen, E.; Breukers, S.; Hisschemoller, M.; Bergsma, E.	2010
3	Stakeholder Engagement In Large-Scale Energy Infrastructure Projects: Revealing Perspectives Using Q Methodology	92	Cuppen, E.; Bosch-Rekveldt, M.G.; Pikaar, E.; Mehos, D.C.	2016
4	"We Don't Take The Pledge": Environmentality And Environmental Skepticism At The Epicenter Of US Wind Energy Development	69	Jepson, W.; Brannstrom, C.; Persons, N.	2012
5	Living With Nuclear Power: A Q-Method Study Of Local Community Perceptions	68	Venables, D.; Pidgeon, N.; Simmons, P.; Henkwood, K.; Parkhill, K.	2009
6	Contrasting The Core Beliefs Regarding The Effective Implementation Of Wind Power. An International Study Of Stakeholder Perspectives	65	Wolsink, M.; Breukers, S.	2010
7	Discourses Of Energy Infrastructure Development: A Q-Method Study Of Electricity Transmission Line Siting In The UK	57	Cotton, M.; Devine-Wright, P.	2011
8	Social Perspectives On Wind-Power Development In West Texas	53	Brannstrom, C.; Jepson, W.; Persons, N.	2011
9	Stakeholder Perspectives On Shale Gas Fracking: A Q-Method Study Of Environmental Discourses	50	Cotton, M.	2015
10	Do Stakeholders' Perspectives On Renewable Energy Infrastructure Pose A Risk To Energy Policy Implementation? A Case Of A Hydropower Plant In Switzerland	41	Diaz, P.; Adler, C.; Patt, A.	2017

Source: Own elaboration based in R results.

3.1.5. Publications by keywords

Figure 4 merges a frequency table and a word cloud offering insights into the key themes of the analyzed publications. As anticipated, the term Q-methodology, is the most prominent, appearing 49, followed by Stakeholders follow which occurs 8 times. Adittionally, several terms related to energy and policy stand out, such as Renewable Energy, Wind energy, Energy Transition, and Energy Policy each mentioned

four times. This indicates a significant focus on the social and political aspects of renewable energy implementation within the field. Moreover, the recurring use of terms like “Acceptance,” “Participation,” “Barriers,” and “Stakeholders Dialogue” indicates that Q-methodology has been extensively utilized to explore community reactions, engagement strategies, and governance issues in renewable energy initiatives. Additionally, mentioning locations such as “Brazil” and “Pakistan” emphasizes this research area’s global and context-oriented aspects.

This distribution of keywords highlights the critical importance of Q-methodology in revealing the human aspects of renewable energy transitions, especially concerning social legitimacy, procedural inclusion, and conflict resolution.



Frequency	Terms
49	Q-methodology
8	Stakeholders
4	Discourses, Energy Policy, Energy Transition, Renewable, Renewable Energy, Wind Energy.
3	Acceptance, Barriers, Biomass, Brazil, Pakistan, Participation, Perspectives, Stakeholders Dialogue, Sustainability

Figure 4. Word cloud of publications based in author keywords. Source: Own elaboration based in R results.

3.2. Relational analysis

A second section will take a relational approach to address specific objectives 2 and 3. SO2, analyze connections within the research through the bibliographic coupling of publications, which identifies thematic areas by linking documents that share references and further exploring these themes by identifying key topics through the frequency and co-occurrence of keywords. SO3 maps the collaboration networks among authors, countries, and institutions researching.

3.2.1. Bibliographic coupling network.

Co-citation analysis and bibliographic coupling are recognized methods for mapping a scientific field’s conceptual and intellectual framework [20]. While co-citation examines the combined impact of previous studies based on the frequency of their joint citations, bibliographic coupling reveals the thematic closeness of current studies referencing similar materials. This approach efficiently identifies ongoing research trends and emerging topics [29,30]. Bibliographic coupling offers a pertinent methodological perspective for illustrating the current research landscape using Q-methodology in the energy sector.

To pinpoint the most representative studies, we selected those with at least 24 citations, surpassing the dataset's average of 23.4 citations per article (see Table 2). Using VOSviewer, we created a bibliographic coupling network composed of 23 documents that met this criterion. The visual representation (Figure 5) displays the articles as nodes, with the size of each node reflecting the number of references. At the same time, the links' thickness illustrates the coupling's strength. Based on the shared references, we identified three distinct clusters, each representing a coherent thematic area concerning Q-methodology applications in energy-related research.

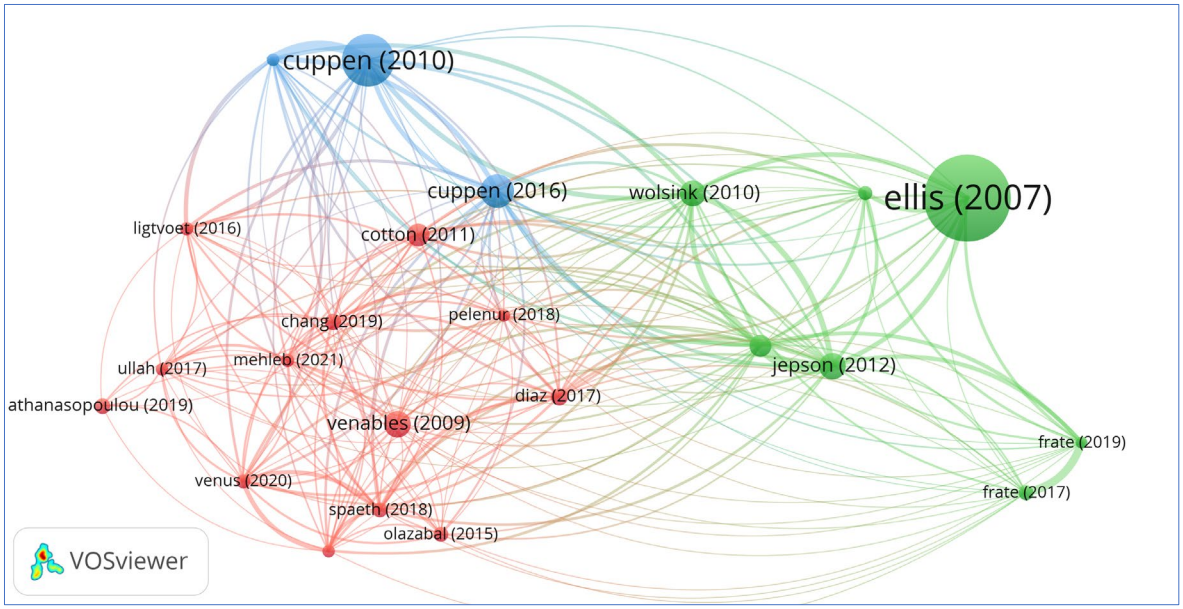


Figure 5. Bibliographic coupling network. Source: VOSviewer results.

The clustering analysis indicates that many impactful studies utilizing Q-methodology concentrate on renewable energy technologies and their socio-political aspects. This highlights the method's importance in tackling significant challenges in energy transitions, especially concerning public legitimacy, environmental justice, and participatory governance. Below, the three identified clusters are outlined:

(1) Environmental Justice and Social Acceptance of Renewable Energy (Green cluster)

This cluster combines studies applying Q-methodology to explore public responses to renewable energy infrastructures, particularly wind and solar projects. Instead of attributing resistance to NIMBYism, these studies highlight concerns rooted in perceptions of fairness, trust in governance, and local identity. Ellis, Barry and Robinson (2007) [25] and Jepson, Brannstrom and Persons (2012) [31] demonstrate how opposition to wind energy reflects deeper socio-political dynamics. Fisher and Brown (2009) [32] examine value conflicts in wind development in Scotland, while Frate and Brannstrom (2017, 2019) [33,34] extend these debates to wind and solar projects in Brazil, integrating justice considerations. Wolsink and Breukers (2010) [35] add a comparative international perspective, showing how institutional settings shape acceptance. These works reveal that Q-methodology helps uncover diverse discourses of acceptance and resistance, supporting more inclusive energy transitions.

(2) Renewable Energy Technologies and Policy Tensions (Red cluster)

The second cluster examines stakeholder views on renewable technologies, governance challenges, and associated trade-offs. Research, such as Venus *et al.* (2020) [36] on run-of-the-river hydropower, Späth

(2018) [37] concerning land-use conflicts in solar development, and Chang *et al.* (2019) [38] regarding BIPV policies, utilizes Q-methodology to reveal competing stakeholder priorities. Diaz *et al.* (2017) [28] investigate hydropower governance in Switzerland, while Venables *et al.* (2009) [39] examine public attitudes towards nuclear energy. Cotton and Devine-Wright (2011) [40] and Ligtvoet *et al.* (2016) [41] evaluate the future of gas and the transmission infrastructure amid energy transitions. Additionally, Mehleb, Lallis and Zografos (2021) [42] reflects on public opinions regarding fiscal tools and urban energy plans. These studies highlight Q-methodology's effectiveness in uncovering governance gaps, stakeholder misalignments, and key political barriers to deploying renewable energy.

(3) Participatory Governance and Methodological Innovation (Blue cluster)

This cluster encompasses studies utilizing Q-methodology to enhance inclusive governance processes. Cuppen *et al.*'s (2010, 2012, 2016) [26,43,44] works are pivotal, demonstrating how Q-methodology can organize stakeholder dialogues, encourage reflexive learning, and steer deliberative engagement in settings such as biomass and infrastructure initiatives. These studies position Q not just as a means to capture perspectives, but also as a tool for promoting pluralistic governance and mediating conflicts. Although more focused on methodology, this cluster is intricately connected to renewable energy discussions by aiding in designing participatory frameworks that are crucial for handling contested projects.

Bibliographic coupling analysis through Q-methodology has uncovered several vital insights. In renewable energy, Q studies indicate that public acceptance of technologies like wind power, solar PV, and hydropower is influenced by technical factors and perceptions of procedural fairness, trust in governing bodies, and emotional or territorial connections. These results challenge simplistic views of public dissent. In governance and policy studies, Q-methodology has shed light on the differing opinions of stakeholders regarding ecological trade-offs, the legitimacy of policies, and the tension between national priorities and regional autonomy. Moreover, in participatory research, Q has been particularly effective in highlighting hidden conflicts, organizing deliberative processes, and fostering mutual learning in complex energy projects. These insights underscore the unique importance of Q-methodology in uncovering subjective viewpoints essential for understanding and promoting more inclusive and context-sensitive energy transitions.

3.2.2. Keywords co-occurrence and thematic map

Integrating keyword co-occurrence analysis with bibliographic coupling enables the identification of more precise study topics in the field. If we asume the themes identified in the bibliographic coupling are reflected in the terms of the co-word analysis, then it is possible to strengthen the coherence of the research landscape. Figure 6, creates using VOSviewer, depitcts a network of co-occurring author keywords in research surrounding Q-methodology and similar subjects. The nodes symbolize essential terms or concepts, while the lines connecting them illustrate e their co-occurrence in published works. The diverse colors represent thematic clusters that group related terms frequently found together in research. The minimum keyword set in the dataset is 2; following this filter, 33 keywords ultimately met the criteria.

At the network's core lies Q-methodology, intricately linked to essential concepts such as renewable energy, stakeholders, and climate change. The term renewable energy emerges stands out as a primary focus of the research, affirming the discipline's thematic orientation toward sustainability and low-carbon

transitions. Its robust connections to terms such as energy transition, stakeholders, and energy efficiency indicate a holistic approach to examining the social, political and institutional dynamics that influence the adoption of renewable energy technologies. The keyword stakeholders is frequently mentioned, demonstrating significant associations with related terms such as stakeholder engagement and perspectives. This underscores the necessity of incorporating key actors in energy projects within decision-making processes and addressing public concerns regarding renewables. Furthermore, the term energy transition emerges as a prominent keyword closely associated with renewable energy and energy efficiency. This term encapsulates the primary objective of shifting from fossil fuels to cleaner energy sources. Various phrases refer to region-specific or case-specific studies, including Brazil, Texas, and wind energy, thereby emphasizing the geographically specific character of Q-methodology applications and their function in addressing localized social reactions to renewable infrastructure.

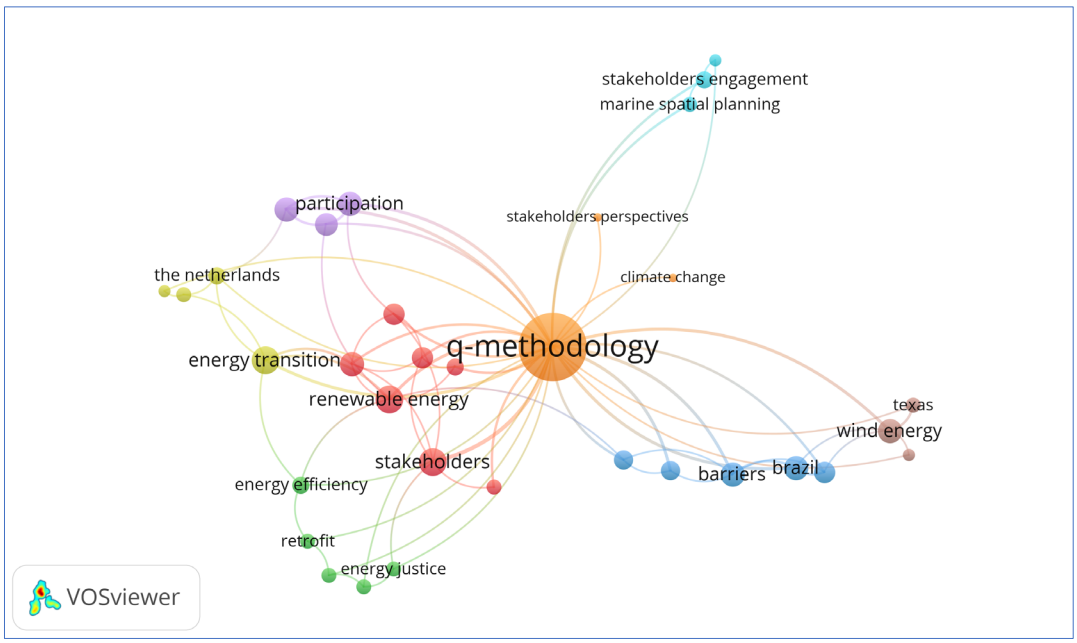


Figure 6. Author keywords co-ocurrence network. Source: VOSviewer results.

A thematic map in Bibliometrix serves as a tool that visually organizes research topics according to their relevance (centrality) and development (density). Additionally, it offers a strategic overview of a field, illustrating which topics are central, foundational, or emerging. Furthermore, it facilitates the identification of the structure of a research field by categorizing topics into four quadrants (Figure 7).

- Motor themes are pivotal in advancing the discipline, signifying a thoroughly developed domain that propels progress and interlinks other fundamental concepts. Participatory methods, such as Q-methodology, stakeholder interaction, and renewable energy policies, converge with theory, methodology, and practical application. Their significance underscores the strategic function of Q-methodology in investigating the societal aspects of the energy transition and fostering equitable and participatory renewable energy governance.
- Niche Themes exhibit a high degree of internal development but remain peripheral to the broader intellectual structure of the field. The prominence of terms such as ‘UK’ and ‘sustainability transformations’ indicates a regionally concentrated scholarly focus, particularly on place-based transitions and locally contextualized pathways to sustainability. Although these themes display

conceptual maturity, their limited centrality suggests they are not yet widely integrated into mainstream debates within the energy and sustainability research landscape.

- Basic Themes form the field's conceptual foundation but require further development. Energy justice and stakeholder perspectives are essential for ensuring social and environmental sustainability, making them clear priorities for future research. Their classification as basic suggests that while conceptually central, they remain underexplored in empirical studies and represent promising avenues for expansion.
- Emerging or declining Themes are either in an early stage or declining. Despite their centrality to climate and energy policy, energy transition and energy efficiency are located in this quadrant, suggesting either fragmentation in research approaches or the need for renewed integration into the evolving discourse. Terms like conflict and wind energy may be tied to specific studies or localized opposition cases, which point to refining these themes through comparative or longitudinal approaches.

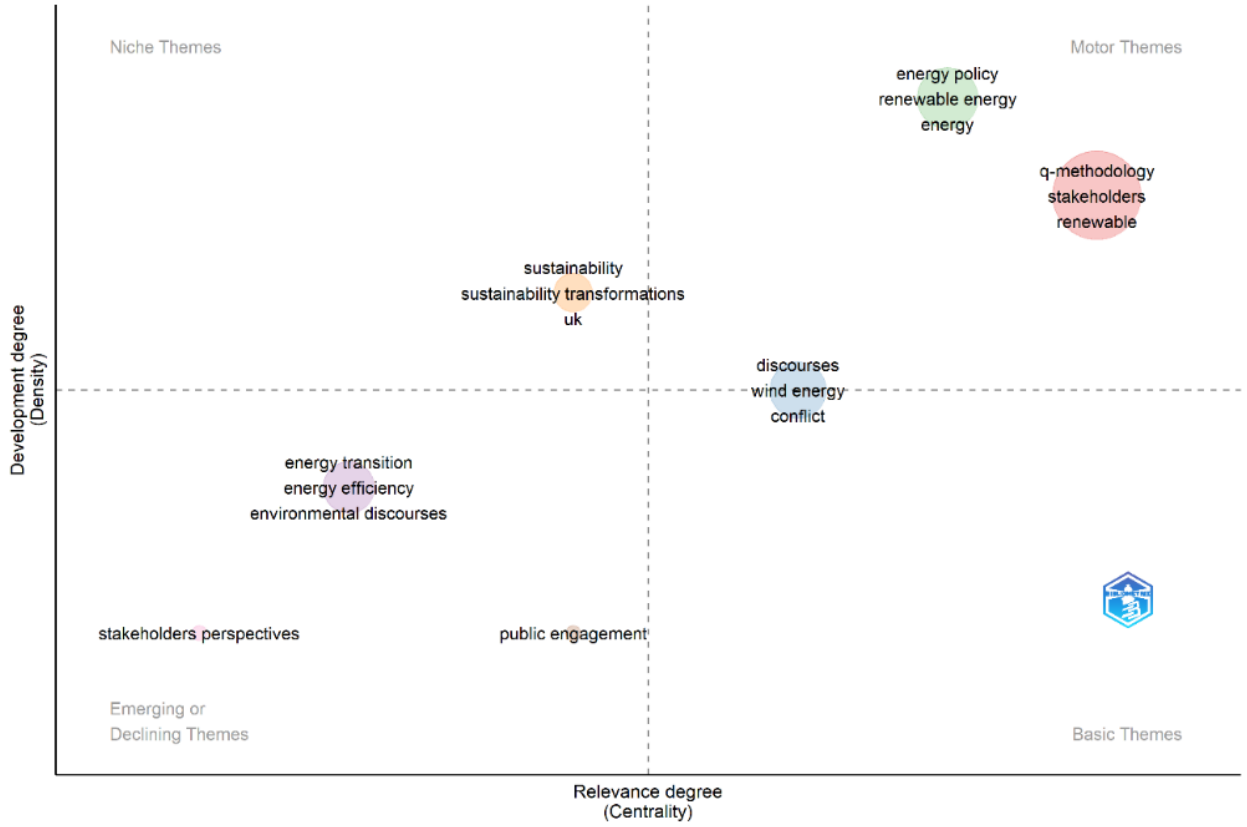


Figure 7. Thematic map. Source: Own elaboration based in R results.

While the co-word analysis and thematic mapping provide a useful overview of the main conceptual lines in the literature, it is important to acknowledge the limitations of the bibliometric approach itself. Tools like Bibliometrix and VOSviewer are powerful for detecting trends, author networks, and recurring themes, but they are inherently descriptive. They do not offer theoretical interpretation on their own. For this reason, we believe it is essential to frame these outputs within broader conceptual debates in energy transition studies—including socio-technical change, participatory governance, and energy justice. This interpretive layer allows us to go beyond quantification and reflect on how the use of Q-methodology connects to deeper epistemic shifts in the way energy transitions are governed and studied.

3.2.3. Collaboration networks

In this section, specific objective 3 (SO3) is addressed by exploring existing collaborations between authors, countries, and institutions.

(a) Author's collaboration

VOSviewer displays a co-authorship network in energy research and related topics, where each node represents a researcher, and the connections between them indicate collaborations in publications. The colors represent clusters or research groups focusing on similar or related topics. The VOSviewer graph shows several key relationships and collaborations within the research community focused on energy and Q-methodology. Figure 8 highlights the articles showcasing cooperation between authors. The graph reveals a wide diversity of researchers from different regions and disciplines. The variety of clusters and the dispersion of nodes suggest that energy research involves multiple specialties. Among the most prominent authors is E. Cuppen, who holds a central position within the red cluster. C. Brannstrom leads the densely connected orange cluster, collaborating with C. Frate and W. Jepson.

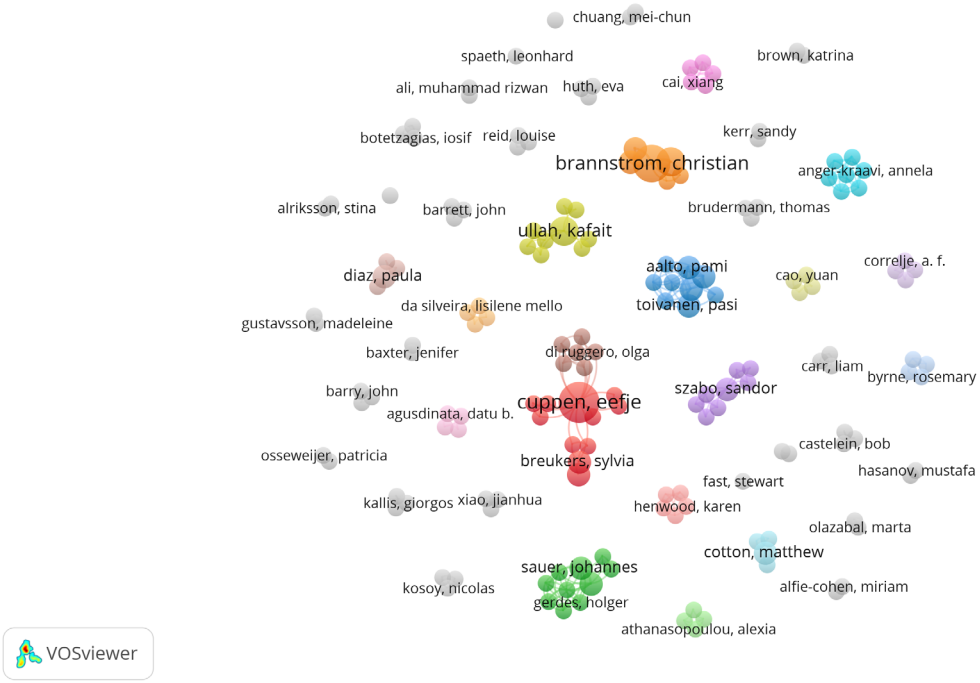


Figure 8. Author collaboration network (co-autorships). Source: VOSviewer results.

(b) Countries and institutions collaboration

Through VOSviewer analysis of the bibliographic coupling of countries and organizations, the countries are grouped into 4 clusters, indicating those that have connections within the same thematic research group. Figure 9a shows that countries like the United Kingdom, the USA, and the Netherlands are crucial intermediaries in the network in terms of influence and direct connectivity. Figure 9b shows academic institutions' varying roles and influences in the research network. Delft University of Technology is one of the most influential institutions, with many connections within its cluster. Its size and centrality in the graph indicate a higher number of collaborations or shared publications within its cluster. Although Texas A&M is not the largest node in the graph, its size suggests a significant role in

collaborations within its cluster. Its connection with the University of Brasília and the Federal University of Ceará suggests transnational collaborations between the United States and Brazil.

(a) (b)

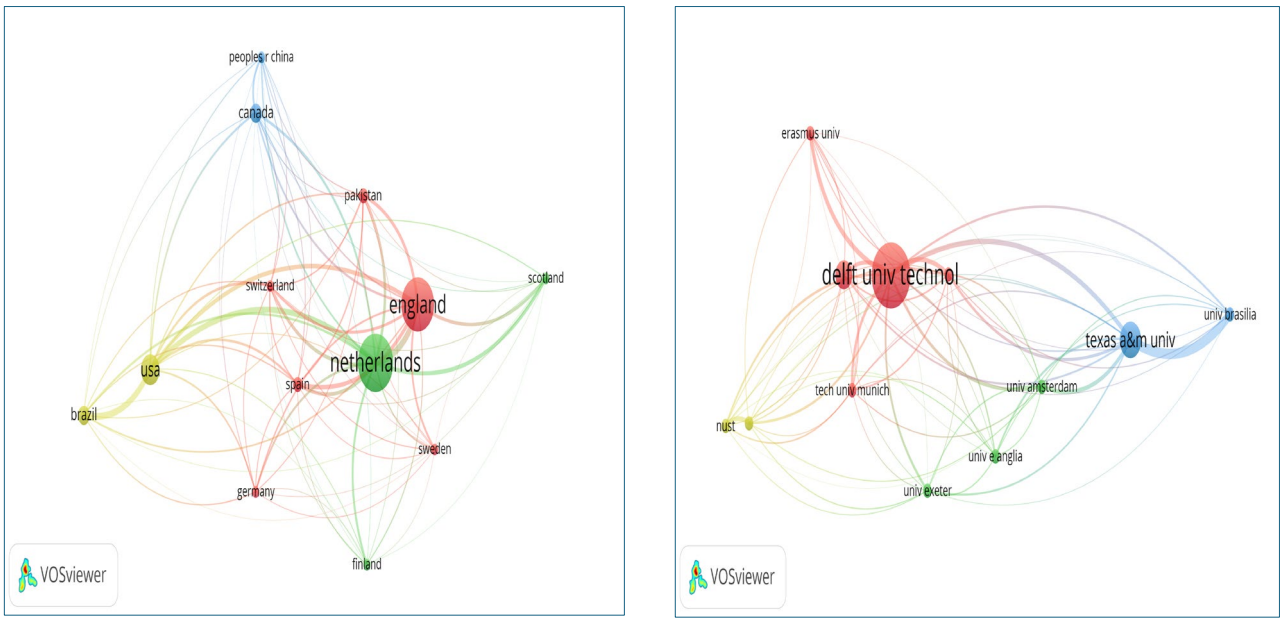


Figure 9. Collaboration network. **(a)** Countries collaboration network; **(b)** Institution collaboration network. Source: VOSviewer results.

4. Conclusion

This study presents the first comprehensive bibliometric analysis of Q-methodology applications in the energy sector with a particular focus on its contributions to understanding the social and political dimensions of renewable energy transitions. Drawing on a dataset 76 articles retrieved from Scopus and Web of Science and applying analytical tools such as Bibliometrix and VOSviewer, this research systematically maps structural and thematic evolution of this research field over a 17-year period.

Beyond the patterns identified in our bibliometric analysis, it is also necessary to reflect critically on the methodological features and limitations of Q-methodology itself. While it is widely appreciated for its ability to uncover subjective viewpoints and organize structured dialogue, it also has important constraints. These include limited generalizability due to small and purposive samples, the strong influence of contextual settings, and the risk of overinterpreting factor structures as fixed social positions. Moreover, although Q-methodology can support inclusive policy dialogue, its integration into policymaking often requires complementary participatory mechanisms. Recognizing these limitations is essential when positioning Q-methodology as a tool for shaping participatory and socially responsive energy governance.

Regarding the first objective (SO1), which sought to identify key academic interests and publication patterns, the results show that Q-methodology has been predominantly employed to investigate stakeholder engagement, public acceptance of renewable energy technologies, and energy policy development. The thematic evolution of the field reflects a shift from general participatory governance

frameworks to more focused analyses of renewable energy technologies, including wind power, solar PV, bioenergy, and hydropower, as well as urban innovations such as building-integrated photovoltaics (BIPV). The most influential publications are concentrated in journals like Energy Policy and Energy Research & Social Science, with prominent institutional contributors such as Delft University of Technology and Texas A&M University. These patterns confirm the geographic and institutional clustering of research efforts in Europe and North America, and underline the centrality of social dimensions in energy transition debates.

The second objective SO2, aimed to identify the main thematic areas addressed by Q-methodology applications in the energy field. Through bibliographic coupling, three core clusters were identified. The first cluster centers on social acceptance and energy justice, particularly in relation to wind and solar projects. It shows how Q-methodology has been used to uncover divergent stakeholder narratives, concerns about procedural and distributive justice, and tensions around institutional trust and territorial identity. The second cluster focuses on policy design and governance, where Q-methodology has been instrumental in eliciting stakeholder perspectives on renewable energy trade-offs, governance misalignments, and the socio-political feasibility of energy transition pathways—especially in the case of hydropower, biogas, and urban solar systems. The third cluster highlights participatory methods and stakeholder dialogue, where Q-methodology serves not only to analyze perspectives but also to structure deliberative processes, promote reflexive learning, and support inclusive governance in contested energy infrastructures. These thematic patterns are not only indicative of academic trends but also resonate with real-world governance challenges in the context of energy transitions. The first cluster, focused on public acceptance and justice, highlights the central role of fairness and trust in shaping community responses to renewable projects. The second cluster brings attention to trade-offs and misalignments in energy governance, particularly in relation to hydropower, solar, and bioenergy deployment. The third cluster emphasizes how Q-methodology has been used not just to study, but to facilitate participatory processes in decision-making. Taken together, these insights suggest that Q-methodology can be a valuable component of inclusive, multi-actor policy frameworks—especially when embedded in broader institutional strategies.

For the third objective (SO3), which analyzed collaboration networks among authors, countries, and institutions, the study reveals a robust architecture of international research partnerships, particularly among institutions in the United Kingdom, the Netherlands, and the United States. Delft University of Technology stands out as a key institutional node. These collaborative patterns reflect the interdisciplinary and transnational nature of Q-methodology applications in energy research, and their alignment with the multi-actor challenges that define contemporary energy transitions. In conclusion, this study demonstrates that Q-methodology is not merely a technique for capturing subjective viewpoints, but a strategic lens for analyzing conflict, complexity, and value plurality in renewable energy systems. Across technologies and contexts, Q-methodology has contributed to a deeper understanding of stakeholder alignment, opposition, and negotiation in energy transitions. Its ability to support inclusive, participatory, and justice-sensitive governance models makes it a valuable tool for addressing the social challenges of decarbonization. Future research should seek to deepen its application in energy policy design, broaden its geographic reach, and integrate it with other methodological frameworks in environmental justice, behavioral energy studies, and systems thinking, to fully leverage its potential in shaping fair and effective renewable energy futures.

Building on the insights provided here, we suggest several directions for future research. First, bibliometric studies on Q-methodology could be enriched by combining them with qualitative reviews or meta-analyses to better understand how discursive findings translate into policy impact. Second, broadening the scope to include grey literature and non-English publications may capture underrepresented perspectives, especially from regions in the Global South. Finally, combining Q-methodology with other participatory or critical approaches—such as discourse analysis, participatory action research, or systems thinking—may enhance its relevance for multi-level energy governance and justice-oriented policy design.

Authors' contribution

Conceptualization and design: Francisco Javier Ramos Real; methodology: M. Lilibeth Fuentes Medina, Iván Medina Jiménez; formal analysis: M. Lilibeth Fuentes Medina, Francisco Javier Calero García; investigation and data curation: M. Lilibeth Fuentes Medina, Francisco Javier Calero García, Francisco Javier Ramos Real, Iván Medina Jiménez; validation: Iván Medina Jiménez; writing—original draft preparation: M. Lilibeth Fuentes Medina; writing—review and editing: Francisco Javier Calero García, Francisco Javier Ramos Real, Iván Medina Jiménez; supervision: Francisco Javier Ramos Real. All authors have read and agreed to the published version of the manuscript.

Conflicts of interests

The authors declare no conflict of interest.

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