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ORIGINAL ARTICLE

Ten years of *Energy Efficiency*: a bibliometric analysis

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Abstract *Energy Efficiency* is an international journal dedicated to research topics connected to energy with a focus on end-use efficiency issues. In 2018, the journal celebrates its 10th anniversary. In order to mark it and analyze not only how the journal has been performing over the years, but also which are the trends for academic debate and research in this journal, this article presents a bibliometric overview of the publication and citation structure of the journal during period 2008–2017. The study relies on the Web of Science Core Collection and the Scopus database to collect the bibliographic results. Additionally, the work exploits the visualization of similarities (VOS) viewer software to map graphically the bibliographic material. The research analyses the most cited papers and the most popular keywords. Moreover, the paper studies how the journal connects with other international journals and identifies the most productive authors, institutions, and countries. The results indicate that the journal has rapidly grown over the years, obtained a merited position in the scientific community, with contributions from authors all over the world (with Europe as the most productive region). Moreover, the journal has focused so far mainly on energy efficiency issues in close relationship with policies and incentives, corporate energy efficiency, consumer behavior, and demand-side management programs, with both industrial, building and transport sectors widely involved. Our discussion concludes with suggested future research avenues, in particular towards coordinated efforts from different disciplines (technical, economic, and sociopsychological ones) to address the emerging energy efficiency challenges.

Keywords Energy efficiency · Bibliometric analysis · Co-citation · VOS viewer

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Introduction

End-use energy efficiency is a major area of energy and climate policy and research. Under "end-use energy efficiency" are included both measures improving the efficiency of the energy services provided (i.e., the provision of the same service with less energy input) as well as measures for the energy conservation, irrespective of the technology adopted (i.e., switching off a lamp, lowering the thermostat, etc.) (Bertoldi et al. 2013). Energy efficiency started to attract the attention of policy makers and researchers in the 1970s, at the time of the first oil embargo by OPEC in 1973, following the Yom Kipur War, when there was a sudden increase in the oil prices, and again in 1979 after the first oil crisis (Grossman 2015; Rüdiger 2019), which led to relevant concerns also in terms of energy security of supply. One key measure at the time to reduce oil import was the improvement of road vehicles efficiency (Geller et al. 1994). Following the first IPCC Assessment Report in 1990 and the establishment of the UNFCC in 1992, there was shared scientific evidence on the causes of climate change and on the need to mitigate the impact of climate change through the reduction of CO_2 emissions due to fossil fuel combustion (Bertoldi 2018). Energy efficiency was highlighted by researchers and policy makers as one of the key mitigation opportunities (Bertoldi 2018). This triggered new and additional scientific research in energy efficiency and associated policies.

One of the key research topics was the "energy efficiency gap" (Jaffe and Stavins 1994). Energy efficiency investments are often cost-effective in the sense that the capital invested is paid back within a few years. However, the investments in energy efficiency are not happening as expected due to a number of well-investigated barriers (Hirst and Brown 1990). Researchers focused on the "barriers" to energy efficiency investments and on the possible policies and measures to eliminate or reduce these barriers (Sorrell et al. 2004; Cagno et al. 2013).

Additional key topics of energy efficiency research related to barriers and policies that have emerged over the last 20 years are the rebound effect (Nassen and Holmberg 2009; Ruzzenenti and Bertoldi 2017; Barker et al. 2009); the evaluation of energy efficiency policies (Brown et al. 2014; Vine 2008; Cooper 2018); the understanding of the consumers and organizations behavior in relation to energy use and efficiency (e.g., Thollander et al. 2007; Cooremans 2011; Cooremans 2012).

The energy efficiency policy landscape in the past 50 years has evolved from individual policies to comprehensive national energy efficiency strategies remaining a key component of national energy and climate policies (Bertoldi 2019). Recently, the European Commission announced the concept of "Energy Efficiency First" in its 2030 strategy, i.e., energy efficiency should be first considered in any decision related to energy use (EC 2018).

Notwithstanding the importance of energy efficiency in energy and climate research, the discussion over energy efficiency challenges did not have a dedicated journal where researchers from different disciplines (e.g., technologies and engineers, economists, psychologists, sociologists, political science researchers) could present their findings (very often of multidisciplinary nature). Some journals, such as *Energy Policy*, cover energy policies issues in all energy areas, from energy sources and production to distribution and energy markets, finally also covering end-use energy efficiency. Some other journals are rather devoted to specific end-use sectors such as buildings (Energy in Buildings) or industry (Journal of Cleaner Production).

Energy Efficiency was launched in 2008 as a research journal focused only on end-use energy efficiency and energy conservation. *Energy Efficiency* is a multidisciplinary journal linking different disciplines from engineers and economics to social and political science and to psychology. The major focus of *Energy Efficiency* has been on energy efficiency, conservation, and demand reductions policies, with particular attention to economics and consumer behavior studies (Bertoldi 2008; Bertoldi 2018). Over the 10 years of *Energy Efficiency*, some of the most prominent researchers in the field have published at least one article within the journal. Given that in 2018, the journal celebrates its 10th anniversary, it is interesting to analyze not only how the journal has been performing over the years, but also which are the trends for academic debate and research in this journal. To do so, in this study we present a bibliometric overview of the publication and citation structure of the journal during the period 2008–2017.

The remainder of the paper is organized as follows. In "Methods," we review the bibliometric methods of the work, devoting "Results" to the presentation of our findings, according to the Web of Science Core Collection and Scopus collection databases. "Mapping Energy Efficiency with VOS viewer software" develops a graphical mapping of the bibliographic material by means of the VOS viewer software, while in "Conclusions," we conclude the paper summarizing the main findings and sketching future research avenues.

Methods

This work relies on the Web of Science (WoS) Core Collection database to collect the bibliographic information (Merigó et al. 2015). This study searches the *Energy Efficiency* journal in WoS database selection the option of "publication name". On August 20, 2018, the search finds 600 documents published in the journal. If we exclude 2018, 528 documents can be found. We have excluded 2018 as the analysis focuses on the first ten full years (2008–2017). In order to focus on scientific contributions, the present work limits considerations exclusively to manuscripts classified as "articles" and "reviews". As a consequence, the number of articles available for the analysis decreases to 514 documents.

In order to analyze the bibliographic material of documents published in *Energy Efficiency*, the paper adopts a bibliometric methodology (Merigó and Yang 2017). The development of a bibliometric analysis of a journal is an approach becoming very popular in the literature. The main reason relies on the celebration of a special event like an anniversary, where journals are usually open to develop some retrospective evaluation and the use of a bibliometric methodology is a particularly suitable technique. Cobo et al. (2015) study the first 25 years of *Knowledge-Based Systems*. Zou et al. (2017) study the first 23 years of documents published in the *Journal of Cleaner Production*. Ji et al. (2018) analyze the first 30 years of *Resources Conservation and Recycling* and Cancino et al. (2017), the first 40 years of *Computers & Industrial Engineering*. Laengle et al. (2017) present a bibliometric overview of the first 40 years of the *European Journal of Operational Research* and Martinez-Lopez et al. (2018) of the *European Journal of Marketing*. Merigó et al. (2018) and Yu et al. (2018a) develop a bibliometric analysis of the first 50 years of *Information Sciences*. Yu et al. (2018b) analyze the *IEEE Transactions on Fuzzy Systems* and Yu et al. (2017) the *Applied Intelligence* journal. Therefore, a bibliometric analysis of the *Energy Efficiency* journal publications showcases the most relevant thematic areas covered in these first 10 years of the journal, as well as how it connects with other international peer-reviewed journals and identifies the most productive authors, institutions, and countries.

In order to measure and analyze the information (Ding et al. 2014), the work exploits several bibliometric indicators (Tur-Porcar et al. 2018) including the total number of publications and citations, the *h*-index (Alonso et al. 2009; Hirsch 2005), the cites per paper and citation thresholds (Merigó et al. 2017). The choice for multiple indicators is, on the one hand, due to a lack of consensus on the optimal indicator for measuring academic research; on the other hand, as multiple indicators may offer a more comprehensive and multifaceted measurement of the journal performance. Still, so far, the most popular indicators are represented by the number of papers and citations. The first measures the journal productivity, while the latter rather looks at the influence and popularity of a given manuscript (Podsakoff et al. 2008). However, the importance for each of them in the analysis is yet unclear, since sometimes a decision-maker could give more importance to productivity than on the number of citations (Merigó et al. 2015), influencing editorial decisions. Therefore, by looking at multiple indicators, a reader may get a better picture of the results in order to draw more appropriate conclusions.

Another approach for results representation is through a graphical analysis that can graphically visualize how the leading elements of the journal (either authors, institutions, or keywords) connect with each other. In order to do so, the present work relies on the VOS viewer software (Van Eck and Waltman 2010) and develops graphical maps by using co-citation (Small 1973), bibliographic coupling (Kessler 1963) and co-occurrence of author keywords (Wang et al. 2018). It is worth recalling some important elements: (i) co-citation occurs when two documents receive a citation from the same third document; (ii) bibliographic coupling appears when two documents cite the same third document; and (iii) co-occurrence of author keywords measures those keywords appearing more frequently in the same documents.

Results

In the following, we report the findings from the bibliometric analyses, first by looking at the publication and citation structure of the *Energy Efficiency* journal, followed by an analysis of the influential documents in terms of citations and authorship.

Publication and citation structure of energy efficiency

Figure 1 shows the number of papers published by the journal over the last decade as well as the average number of manuscripts per volume. *Energy Efficiency* started publishing articles in 2008. As can be clearly inferred, the journal consistently grew over the years, almost quadruplicating from the very first 24 publications in 2008. Interestingly, the curve shaped its largest growth over the last 5 years, shifting from 45 publications in 2013 up to 93 in 2017. Moreover, at the very beginning, the journal was structured with four issues (from 2008 to 2013), then increasing to six issues per year. Therefore, it can be noted that the journal has significantly increased the number of manuscripts published per single issue, from about six per volume in 2008 to more than 15 in 2017. In this regard, we have further investigated with *Energy Efficiency* journal manager the reasons driving this increase. Interestingly, it emerged that the increase is neither due to a different marketing strategy nor dissemination activities, not either to a different approach to journal reviews. Rather, the remarkable growth is due to a natural diffusion of the information about the existence of the journal itself, with its aim and scope that led to an increased number of submissions (as discussed further).

Additionally, always considering the period 2007–2017, when taking a closer look to the presence of special volumes, the journal has so far taken an approach predominantly focused on regular issues, with the vast majority of special volumes in the very beginning (7 out of the 8 special volumes have been published before 2014, 5 of which before 2010).

Compared to other journals operating in the energy field, *Energy Efficiency* could be considered as a niche journal, very much focused on a relatively limited number of topics wide-ranging over "energy savings, energy consumption, energy sufficiency, and energy transition in all sectors" (as from the *Energy Efficiency* journal website). Nevertheless, the constant positive trend of the number of citations (as shown in Table 1), strongly confirmed also by analyzing the set of manuscripts excluding self-citations (of all authors), shows that the journal has obtained a merited position in the scientific community.

Nevertheless, the journal presents an excellent trend in terms of the number of submissions, accepted

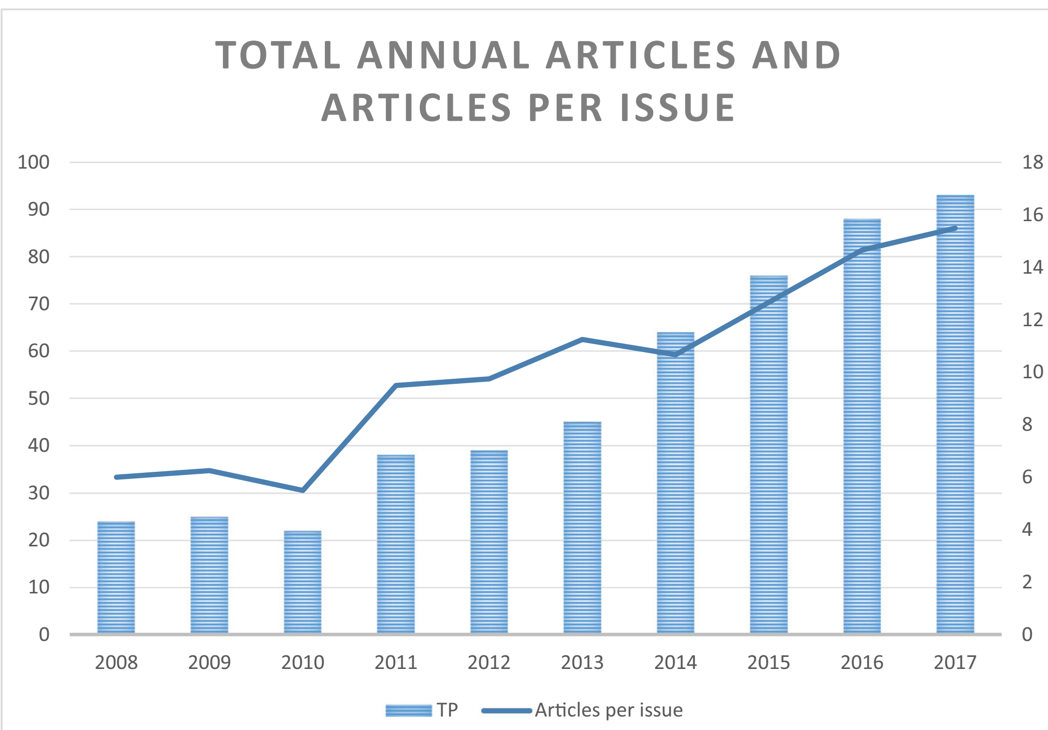

Fig. 1 Annual number of papers published in *Energy Efficiency*

Table 1 Annual citation structure of *Energy Efficiency*

Year	TP	TC	≥ 100	≥ 50	≥ 25	≥ 10	≥5	≥ 1
2008	24	958	2	3	8	13	20	22
2009	25	629	1	3	10	17	21	24
2010	22	308	0	2	4	6	14	21
2011	38	491	0	0	7	18	26	37
2012	39	360	0	0	5	12	22	35
2013	45	438	0	0	5	18	28	39
2014	64	437	0	0	3	13	32	53
2015	76	311	0	0	2	7	17	52
2016	88	206	0	0	0	0	10	44
2017	93	94	0	0	0	0	1	20
Total	514		3	8	44	104	191	347
%	100.00%		0.58%	1.56%	8.56%	20.23%	37.16%	67.51%

Abbreviations: TP and TC= total papers and citations; ≥ 100, ≥ 50, ≥ 25, ≥ 10, ≥ 5, ≥ 1 = number of papers with equal or more than 100, 50, 25, 10, 5, and 1 citations

manuscripts as well as downloads over the years (Fig. 2). Firstly, the number of publications ranges from a minimum of 60 (2009) up to 590 (2017), with significant growth over the last 5 years. Additionally, the remarkable exponential growth in the number of downloads seems to indicate that, over the last decade, the journal has become an acknowledgeable place for the academic debate discussion over energy efficiency issues. Further, regarding accepted manuscripts, two main considerations can be drawn. First, we can note a notable increase, from 25 (in 2008) up to 95 (in 2017). Second, and more interestingly, by simultaneously looking at the submissions also, we can appreciate that the distance between them has significantly enlarged over the years. From earlier values of around 30% in the first 5 years, the journal has dramatically decreased the acceptance rate to around 15% over the last 5 years. This seems to indicate that the average quality of the articles has been increased over the years, in turn, allowing the journal to pursue a strategy of premium quality, thus leading potential authors to perceive the journal as a high aspired to publish in.

By clustering submissions by areas, we can see that the majority of the articles submitted deals with energy efficiency in specific technologies, e.g., internal combustion engines, residential appliances, motor systems,

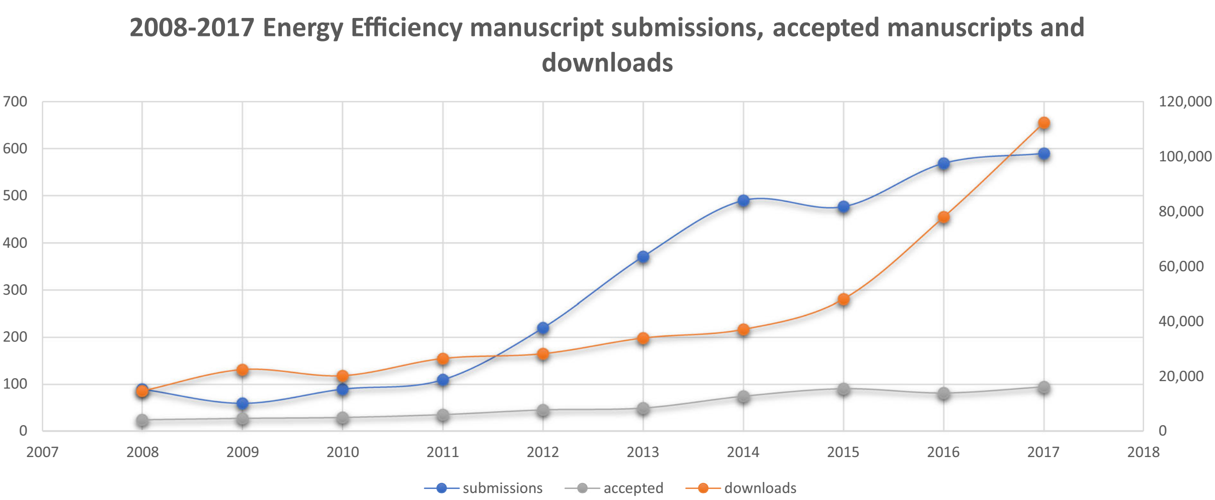

Fig. 2 Annual number of manuscripts submitted and downloaded in *Energy Efficiency* journal

industry, and buildings. In the buildings area, many articles deal with technologies and techniques for buildings refurbishments, such as insulation materials, façade design, natural ventilation, day-lighting, and control systems. However, the strength of *Energy Efficiency* is in relation to analysis and research on energy efficiency policies, including evaluation, and other soft measures to remove barriers to energy efficiency. Key areas of research covered by the "more" successful published papers are evaluation of energy savings including decomposition analysis and/or other econometric techniques; the provision of energy services and ESCOs; market-based instruments (ETS, white certificates, etc.); smart metering and feedback systems; consumer and organization behavior.

Influential papers in *Energy Efficiency*

When taking a further look in the set of most cited documents (as reported by Table 2), we can clearly identify some of the major discussion trends for the *Energy Efficiency* journal. Indeed, the discussion has covered energy efficiency issues for many sectors, mainly residential (e.g., paper nos. 1, 4, 6, 8, 9, 18) and industrial (e.g. paper nos. 2, 3, 10, 13), with additional insights over other sectors (i.e., commercial, transport, and agriculture, respectively; papers 7, 14, 20). Further, we can see that the discussion ranges from a broader set of levels: indeed, we can find either discussion of technologies and policy instruments for improved energy efficiency (e.g., paper nos. 14, 15, 16), discussion of the behavior of final users (in terms of, e.g., barriers and driving forces, paper nos. 3, 10, 11, 19), as well as broader analyses (e.g., papers 5, 20), with additional insights over decision-making issues (e.g., papers 12 and 17).

More in detail, the most cited paper was published by Corinna Fisher and has 450 citations (Fischer 2008). The manuscript presents a psychological model regarding feedback on electricity consumption illustrating how and why feedback works as a tool for customers to better control their consumption and ultimately save energy. The second most cited paper (134 citations) covers another key issue of the journal. It is authored by Ernst Worrell, Lenny Bernstein, Joyashree Roy, Lynn Price, and Jochen Harnisch, who discuss the potential contribution to reduce energy use and GHG emissions in longer term by industrial energy-efficiency technologies and policies (Worrell et al. 2009). The third most cited paper is co-authored by Patrik Thollander and Mikael Ottosson (118 citations), who have explored barriers and driving forces for improved energy efficiency by conducting an investigation in a Swedish pulp and paper industry (Thollander and Ottosson 2008).

Similar considerations can be drawn by looking at the top most cited documents in *Energy Efficiency* publications. As depicted in Table 3, many top 30 most cited articles dispute barriers and drivers for energy efficiency at various levels (e.g., papers 1, 6–11), confirming that the discussion on "which" are the major issues to promote energy efficiency in different contexts, as well as the "how" to overcome them is quite vivid. For this reason, 7 out of the first 20 most cited manuscripts come from *Energy Policy* journal, as well as manuscripts from other journals discussing similar issues. Interestingly, only 3 out of the first 20 most cited documents are published in *Energy Efficiency* journal, showing not only that the journal itself is still in the phase of finding its own room, but also that the manuscripts published in the journal take the benefit of tackling the energy efficiency issue with a multifaceted approach. This, in turn, seems to call for further coordinated efforts from different disciplines (technical, economic and sociopsychological ones) to address the energy efficiency issue.

Leading authors, institutions, and countries

A broad set of authors (1317 authors) has contributed with manuscripts to *Energy Efficiency* in this first decade, and Table 4 presents the most productive ones in the journal, by including several bibliometric indicators for *Energy Efficiency* publications—such as number of manuscripts, total number of citations, h-index, and average number of cites per paper, as well as number of papers with more than 50 and 10 citations, respectively—so to draw a more general picture of the results for each author. Further, it is worth pointing out that only the last author affiliation has been listed. Ernst Worrell, one of the Energy Efficiency Associate Editors, is the most productive author of the journal, with 10 manuscripts. By taking a further look at most productive and influential institutions and countries, as shown by Table 5, we can find a major role by scholars with affiliations in the USA, the Netherlands, Germany, Sweden, and Italy, thanks in part to the work of Ernst Worrell and his colleagues. Moreover, this analysis shows that

Table 2 The 40 most cited documents in *Energy Efficiency* according to WoS

R	TC	Title	Author/s	Year	Citations per year
1	450	Feedback on household electricity consumption: a tool for saving energy?	Fischer, C	2008	45.00
2	134	Industrial energy efficiency and climate change mitigation	Worrell, E; Bernstein, L; Roy, J; et al.	2009	14.89
3	118	An energy efficient Swedish pulp and paper industry—exploring barriers to and driving forces for cost-effective energy efficiency investments	Thollander, P; Ottosson, M	2008	11.80
4	76	Reducing energy use in the buildings sector: measures, costs, and examples	Harvey, LDD	2009	8.44
5	73	The macroeconomic rebound effect and the world economy	Barker, T; Dagoumas, A; Rubin, J	2009	8.11
6	73	Improving the energy performance of UK households: Results from surveys of consumer adoption and use of low- and zero-carbon technologies	Caird, S; Roy, R; Herring, H	2008	7.30
7	67	Potential benefits of cool roofs on commercial buildings: conserving energy, saving money, and reducing emission of greenhouse gases and air pollutants	Levinson, R; Akbari, H	2010	8.38
8	54	Electricity and water consumption for laundry washing by washing machine worldwide	Pakula, C; Stamminger, R	2010	6.75
9	48	What role for microgeneration in a shift to a low carbon domestic energy sector in the UK?	Bergman, N; Eyre, N	2011	6.86
10	46	Barriers to energy efficiency improvement and decision-making behavior in Thai industry	Hasanbeigi, A; Menke, C; du Pont, P	2010	5.75
11	44	New thinking on the agentive relationship between end-use technologies and energy-using practices	Wilhite, H	2008	4.40
12	42	Investment in energy efficiency: do the characteristics of investments matter?	Cooremans, C	2012	7.00
13	39	Energy efficiency in energy-intensive industries-an evaluation of the Swedish voluntary agreement PFE	Stenqvist, C; Nilsson, LJ	2012	6.50
14	39	Energy efficiency technologies for road vehicles	Kobayashi, S; Plotkin, S; Ribeiro, SK	2009	4.33
15	36	Theory-based policy evaluation of 20 energy efficiency instruments	Harmelink, M; Nilsson, L; Harmsen, R	2008	3.60
16	35	Breaking down the silos: the integration of energy efficiency, renewable energy, demand response and climate change	Vine, E	2008	3.50
17	34	Make it strategic! Financial investment logic is not enough	Cooremans, C	2011	4.86
18	34	Bottom-up assessment of potentials and costs of CO2 emission mitigation in the buildings sector: insights into the missing elements	Uerge-Vorsatz, D; Novikova, A; Koeppel, S; et al.	2009	3.78
19	33	Constructing users in the smart grid-insights from the Danish eFlex project	Nyborg, S; Ropke, I	2013	6.60
20	33	Energy intensities and greenhouse gas emission mitigation in global agriculture	Schneider, UA; Smith, P	2009	3.67
21	32	Efficient technologies or user behavior, which is the more important when reducing households' energy consumption?	Gram-Hanssen, K	2013	6.40
22	32	The potential for large-scale savings from insulating residential buildings in the EU	Lechtenboehmer, S; Schuering, A	2011	4.57
23	32	Quantifying the rebound effects of energy efficiency improvements and energy conserving behavior in Sweden	Nassen, J; Holmberg, J	2009	3.56

Table 2 (continued)

R	TC	Title	Author/s	Year	Citations per year
24	39	Lessons from energy efficiency policy and programs in the UK from 1973 to 2013	Mallaburn, PS; Eyre, N	2014	9.75
25	29	Building commissioning: a golden opportunity for reducing energy costs and greenhouse gas emissions in the USA	Mills, E	2011	4.14
26	29	Optimization of parallel variable-speed-driven centrifugal pumps operation	Bortoni, EC; de Almeida, RA; Carvalho V, Augusto N	2008	2.90
27	27	Assessing the energy-efficiency information gap: results from a survey of home energy auditors	Palmer, K; Walls, M; Gordon, H; et al.	2013	5.40
28	27	Building energy information systems: user case studies	Granderson, J; Piette, MA; Ghatikar, G	2011	3.86
29	25	Urban energy consumption and CO2 emissions in Beijing: current and future	Yu, H; Pan, SY; Tang, BJ; et al.	2015	8.33
30	25	Evaluation of European energy behavioral change programs	Gynther, L; Mikkonen, I; Smits, A	2012	4.17
31	25	Driving an electric vehicle. A sociological analysis on pioneer users	Pierre, M; Jemelin, C; Louvet, N	2011	3.57
32	25	Building a business to close the efficiency gap: the Swedish ESCO Experience	Soroye, KL; Nilsson, LJ	2010	3.13
33	25	Incentives for energy efficiency in the EU Emissions Trading Scheme	Schleich, J; Rogge, K; Betz, R	2009	2.78
34	25	Tradable white certificate schemes: fundamental concepts	Bertoldi, P; Rezessy, S	2008	2.50
35	24	The effect of energy end-use efficiency improvement on China's energy use and CO2 emissions: a CGE model-based analysis	Liang, QM; Fan, Y; Wei, YM	2009	2.67
36	23	Energy efficiency evaluation for regions in China: an application of DEA and Malmquist indices	Wu, AH; Cao, YY; Liu, B	2014	5.75
37	23	Electricity generation from low-temperature industrial excess heat-an opportunity for the steel industry	Johansson, MT; Soderstrom, M	2014	5.75
38	23	A bibliometric analysis of recent energy efficiency literatures: an expanding and shifting focus	Du, H; Wei, L; Brown, MA.; et al.	2013	4.60
39	23	Domestic heat pumps in the UK: user behavior, satisfaction and performance	Caird, S; Roy, R; Potter, S	2012	3.83
40	23	Overview of energy consumption and GHG mitigation technologies in the building sector of Japan	Murakami, S; Levine, MD; Yoshino, H; et al.	2009	2.56

Abbreviations: R = Rank

the journal has so far received most of the published contributions by European-based scholars (with the exception of the University of California Berkeley).

Next, by scaling up at country level (Table 6), we can see that the USA are the most productive country, followed by the UK, Germany, Sweden and the Netherlands. Nevertheless, by looking at the number of publications per capita (as number of inhabitants), results are in favor of European countries. In particular, it is worth noting that the highest numbers can be observed for Germany and the Netherlands. Still, while European developed countries are the major contributors, we can interestingly note that non-European developing ones are emerging, in particular, China, India, and Brazil.

Further, let us look into the citing articles of *Energy Efficiency*. The objective here is to identify those actors having cited *Energy Efficiency* the highest number of times. Note that the counting procedure only measures the number of articles independently of the number of citations given to *Energy Efficiency* in each article.

Table 3 Top 30 most cited documents in *Energy Efficiency* publications

Rank	Year	First author	Reference	Vol	Page	Type	TC	Co-citations
1	1994	Jaffe AB	Energ Policy	v22	p804	A	26	23
2	2000	Greening LA	Energ Policy	v28	p389	A	25	25
3	2005	Abrahamse W	J Environ Psychol	v25	p273	A	24	23
4	2008	Fischer C	Energ Effic	v1	p79	A	18	18
5	2006	Darby S	Effectiveness of Feedback on Energy Consumption	–	–	B	17	16
6	2009	Sorrell S	Energ Policy	v37	p1356	A	17	17
7	2008	Thollander P	Energ Effic	v1	p21	A	16	16
8	1990	Hirst E	Resour Conserv Recy	v3	p267	A	14	14
9	2001	De Groot HLF	Energ Econ	v23	p717	A	13	13
10	2006	Rohdin P	Energy	v31	p1836	A	12	12
11	2007	Rohdin P	Energ Policy	v35	p672	A	12	12
12	2003	Worrell E	Energy	v28	p1081	A	12	11
13	2006	Gillingham K	Annu Rev. Env Resour	v31	p161	A	11	11
14	2008	Perez-Lombard L	Energ Buildings	v40	p394	A	11	6
15	2012	Stenqvist C	Energ Effic	v5	p225	A	11	11
16	2007	Thollander P	Energ Policy	v35	p5774	A	11	11
17	1997	Weber L	Energ Polic	v25	p833	A	11	10
18	1991	Ajzen I	Organ Behav Hum Dec	v50	p179	A	10	9
19	2000	Ang BW	Energy	v25	p1149	A	10	10
20	1996	Patterson MG	Energ Policy	v24	p377	A	10	9
21	2000	Sorrell S	Reducing Barriers to Energy Effic	–	–	B	10	10
22	2000	Stern PC	J Soc Issues	v56	p407	A	10	9
23	2008	Zhou P	Energ Policy	v36	p2911	A	10	10
24	2012	Allcott H	J Econ Perspect	v26	p3	A	9	9
25	2004	Ang BW	Energ Policy	v32	p1131	A	9	9
26	2001	Binswanger M	Ecol Econ	v36	p119	A	9	9
27	2000	Harris J	Energ Policy	v28	p867	A	9	9
28	1994	Jaffe AB	Resour Energy Econ	v16	p91	A	9	9
29	2004	Sorrell S	Economics of Energy Efficiency	–	–	B	9	9
30	2004	Anderson ST	Resour Energy Econ	v26	p27	A	8	8

Abbreviations: Vol = volume; TC = total citations

Table 7 present the top 30 citing actors in terms of universities, countries, and authors.

Similar to what found above for the number of publications, the University of California Berkeley (Unites States of America) is the university citing more frequently *Energy Efficiency*, followed by Linköping University (Sweden) and Utrecht University (The Netherlands). Most of the leading institutions are from Europe, although there are also some North American and Asian universities in the list. Interestingly, most of the authors belonging to those universities are focused on energy efficiency issues applied to an industrial context. When generalizing at the country level, the results are consistent with the university level where the USA and China appear well placed in the ranking but, according to their size, their results are less remarkable than those from European countries being the main leaders in Energy Efficiency. Particularly, the results of the UK, Germany, Sweden, the Netherlands and Italy are notable.

Another interesting issue for the analysis of the citing articles is to identify the journals citing in more papers the manuscripts published in *Energy Efficiency*. Figure 3 presents the top 25 journals and classify the results from

Table 4 Leading authors in *Energy Efficiency*

R	Full name	University	TP	TC	H	C/P	> 50	> 10
1	Ernst Worrell	U Utrecht	10	200	6	20.00	1	4
2	Rainer Stamminger	U Bonn	7	91	4	13.00	1	3
3	Edward Vine	U California Berkeley	7	68	5	9.71	0	2
4	Marilyn A. Brown	Georgia Institute of Technology	5	38	3	7.60	0	1
5	Wolfgang Eichhammer	U Utrecht	5	33	4	6.60	0	1
6	Robert Harmsen	U Utrecht	5	45	2	9.00	0	1
7	Evan Mills	U California Berkeley	5	56	3	11.20	0	2
8	Amol Phadke	U California Berkeley	5	9	2	1.80	0	0
9	Tero Ahonen	Lappeenranta U Technology	4	29	2	7.25	0	1
10	Semida Silveira	KTH Royal Inst Technology	4	28	3	7.00	0	1
11	Jussi Tamminen	Lappeenranta U Technology	4	29	2	7.25	0	1
12	Jero Ahola	Lappeenranta U Technology	3	28	2	9.33	0	1
13	Morgan Bazilian	Colorado School of Mines	3	26	3	8.67	0	1
14	Stephen Berry	U South Australia	3	21	2	7.00	0	1
15	Jean-Sebastien Broc	Broc Res & Consulting	3	11	2	3.67	0	0
16	Luisa F. Cabeza	U Lleida	3	19	3	6.33	0	0
17	Caiman J. Cahill	U College Cork	3	21	3	7.00	0	0
18	Albert Castell	U Lleida	3	19	3	6.33	0	0
19	Catherine Cooremans	U Lausanne	3	76	2	25.33	0	2
20	Anibal T. de Almeida	U Coimbra	3	16	2	5.33	0	1
21	Louis-Benoit Desroches	U California Berkeley	3	4	1	1.33	0	0
22	Sally M. Donovan	Imperial College London	3	4	1	1.33	0	0
23	Nick Eyre	U Oxford	3	82	3	27.33	0	2
24	Massimo Filippini	ETH Zurich	3	14	2	4.67	0	0
25	Brian P. O. Gallachoir	U College Cork	3	21	3	7.00	0	0
26	Jeffery B. Greenblatt	U California Berkeley	3	4	1	1.33	0	0
27	Eva Heiskanen	U Helsinki	3	9	2	3.00	0	0
28	Marvin J. Horowitz	Demand Res LLC	3	12	2	4.00	0	0
29	Maria T. Johansson	Linkoping U	3	36	2	12.00	0	2
30	Steve Meyers	U California Berkeley	3	19	3	6.33	0	0
31	Johannes Morfeldt	KTH Royal Inst Technology	3	21	2	7.00	0	1
32	Corinne Moser	Zhaw Zurcher Hsch Angew Wissensch	3	5	1	1.67	0	0
33	Vlasis Oikonomou	JIN Climate and Sustainability	3	16	3	5.33	0	0
34	Dominique Osso	EDF-R&D	3	11	2	3.67	0	0
35	Christiane Pakula	U Hochschule Niederrhein	3	63	3	21.00	1	1
36	Won Y. Park	U California Berkeley	3	3	1	1.00	0	0
37	Ralph Prahl	Prahl & Associates,	3	25	3	8.33	0	1
38	Nihar Shah	Harvard U	3	5	2	1.67	0	0
39	Patrik Thollander	Linkoping U	3	128	2	42.67	1	1
40	Stefan Thomas	Wuppertal Inst Climate	3	23	3	7.67	0	0
41	Juha Viholainen	Lappeenranta U Technology	3	29	2	9.67	0	1
42	Tanja Winther	U Oslo	3	22	2	7.33	0	1

Abbreviations are available in previous tables except for: H = h-index; C/P = cites per paper

Table 5 The most productive and influential institutions in *Energy Efficiency*

R	University	Country	TP	TC	TH	TC/TP	ARWU	QS
1	U California Berkeley	USA	43	543	12	12.63	5	28
2	Utrecht U	Netherlands	15	230	6	15.33	47	104
3	Linkoping U	Sweden	13	219	8	16.85	201–300	–
4	Fraunhofer Gesellschaft	Germany	11	77	5	7.00	–	–
5	Polytechnic U Milan	Italy	9	52	5	5.78	–	183
6	Lund U	Sweden	8	134	6	16.75	101–150	73
7	U Bonn	Germany	8	95	4	11.88	101–151	231
8	U Oxford	UK	8	115	5	14.38	7	6
9	De Montfort U	UK	7	48	3	6.86	–	–
10			7	53	4	7.57	19	8
11	KTH Royal Inst Technology	Sweden	7	56	4	8.00	201–300	97
12	U Coimbra	Portugal	7	22	2	3.14	401–500	451–460
13	King Mongkut's U Techn Thonburi	Thailand	6	74	4	12.33	–	701+
14	Lappeenranta U Technology	Finland	6	33	3	5.50	–	471–480
15	U College Cork	Ireland	6	36	4	6.00	601–700	283
16	Chalmers U Technology	Sweden	5	60	4	12.00	201–300	139
17	Delft U Technology	Netherlands	5	36	2	7.20	151–200	62
18	Electricite de France EDF	France	5	39	2	7.80	–	–
19	Georgia Inst Technology	USA	5	38	3	7.60	85	71
20	Islamic Azad U	Iran	5	9	2	1.80	–	–
21	U College London	UK	5	20	3	4.00	16	7
22	U Geneva	Switzerland	5	82	3	16.40	60	95
23	Aalborg U	Denmark	4	72	3	18.00	201–300	374
24	California Inst Energy Environ	USA	4	20	3	5.00	–	–
25	CNRS France	France	4	43	3	10.75	–	–

Abbreviations are available in previous tables except for: ARWU = Academic Ranking of World Universities; QS = Quacquarelli & Symonds University Ranking

an annual perspective. Given that 2008 is the inaugural year of *Energy Efficiency*, the journal did not obtain any citation for that year. For this reason, the analysis of the annual performance begins in 2009.

As previously noted, *Energy Policy* and the self-citations of *Energy Efficiency* emerge as most recurrent in the journal. Concerning *Energy Policy*, it presents a remarkable wave in the 2012–2015. This could be partially explained by the discussion about the European energy efficiency directive published in 2012, thus with plenty of energy policy manuscripts referring to discussion about how to successfully implement such directive. Regarding self-citations of the Energy efficiency journal, if on the one hand they increased over the years, on the other hand they are overall comparable to other journals. Moreover, *Energy and Buildings*, *Journal of Cleaner Production*, *Applied Energy and Renewable & Sustainable Energy Reviews* also cite significantly the journal. This result seems pretty aligned with previous considerations on the topics covered by the journal and research approaches, showing the interconnections of energy efficiency issues with not only energy-related journals, but also with more sustainability and industrial oriented ones, and, in conclusion, confirming that the journal is finding its space in the academic debate over energy efficiency.

Mapping *Energy Efficiency* with VOS viewer software

In order to deepen into the results of the previous section, we have developed a graphical mapping of the bibliographical material, by relying on the VOS viewer

Table 6 The most productive and influential countries in *Energy Efficiency*

R	Country	TP	TC	TH	TC/TP	> 50	> 10	TP/Pop	TC/Pop
1	USA	116	978	16	8.43	1	3	0.36	3.04
2	UK	49	525	12	10.71	0	2	0.74	7.88
3	Germany	44	1009	14	22.93	2	3	0.54	12.39
4	Sweden	42	518	13	12.33	1	1	4.29	52.86
5	Netherlands	41	476	11	11.61	1	1	2.42	28.10
6	Italy	27	181	8	6.70	0	0	0.44	2.98
7	Peoples R China	27	167	7	6.19	0	0	0.02	0.12
8	Spain	19	82	6	4.32	0	0	0.41	1.77
9	Finland	18	106	6	5.89	0	0	3.28	19.34
10	France	18	140	8	7.78	0	0	0.27	2.10
11	Switzerland	17	184	7	10.82	0	0	2.03	21.98
12	Australia	16	75	5	4.69	0	0	0.67	3.15
13	India	16	191	5	11.94	1	1	0.01	0.15
14	Canada	14	127	4	9.07	1	1	0.39	3.54
15	Portugal	14	42	4	3.00	0	0	1.35	4.06
16	Norway	13	117	6	9.00	0	0	2.50	22.52
17	Brazil	12	107	5	8.92	0	0	0.06	0.52
18	Iran	12	34	4	2.83	0	0	0.15	0.43
19	Ireland	9	49	5	5.44	0	0	1.94	10.56
20	Austria	8	36	4	4.50	0	0	0.91	4.12
21	South Korea	8	9	2	1.13	0	0	0.16	0.18
22	Thailand	8	83	5	10.38	0	0	0.12	1.21
23	Denmark	7	78	4	11.14	0	0	1.23	13.74
24	Greece	7	14	3	2.00	0	0	0.65	1.29
25	Japan	7	88	4	12.57	0	0	0.06	0.69
26	Belgium	5	41	3	8.20	0	0	0.44	3.63
27	Malaysia	5	12	2	2.40	0	0	0.16	0.38
28	Taiwan	5	11	3	2.20	0	0	0.21	0.47
29	Romania	4	15	2	3.75	0	0	0.20	0.76
30	Turkey	4	13	2	3.25	0	0	0.05	0.17

Abbreviations are available in previous tables except for: TP/Pop = total papers per million inhabitants; TC/Pop = total citations million inhabitants

software (Van Eck and Waltman 2010), one of the tools available for the development of a graphical analysis of the bibliographic material (Cobo et al. 2011). VOS viewer collects the bibliographic material producing graphical visualizations by using co-citation (Small 1973), bibliographic coupling (Kessler 1963), and co-occurrence of author keywords (Laengle et al. 2018).

First, we have looked into co-citation of journals, trying to identify the most cited journals in *Energy Efficiency* and connect those journals that more frequently receive citations from the same documents. Figure 4 presents the results considering a minimum citation threshold of ten cites and the 100 strongest co-citation links.

Here, it is worth mentioning the tighter relationship with *Energy Policy* journal, being the most cited journal in *Energy Efficiency*, followed by *Energy and Buildings*, *Energy Efficiency* itself and *Energy*. These journals, together with *Energy Economics*, *Applied Energy and Energy Conversion and Management*, form the main core of the journal. This result clearly visualizes the focus of *Energy Efficiency* around topics connected

Table 7 Citing articles of *Energy Efficiency*: authors, universities, countries, and journals

R	University	TP	Country	TP	Author	TP
1	U California Berkeley	50	USA	388	Thollander P	22
2	Linkoping U	45	UK	304	Stamminger R	21
3	Utrecht U	44	PR China	265	Worrell E	20
4	Fraunhofer Gesellschaft	41	Germany	198	Cagno E	14
5	Polytechnic U Milan	33	Sweden	169	Xia XH	14
6	U Oxford	32	Netherlands	144	Lin BQ	13
7	Delft U Technology	28	Italy	137	Trianni A	13
8	Virginia Polytechnic Inst St U	27	Spain	96	Taylor JE	12
9	Lund U	26	Australia	95	Wei YM	11
10	U College London	26	Canada	79	Eichhammer W	10
11	Chalmers U Technology	25	France	71	Patel MK	10
12	Norwegian U Science Technology	25	Finland	62	Heiskanen E	9
13	Beijing Institute of Technology	24	India	56	Levinson R	9
14	Royal Institute of Technology	24	Japan	56	Oikonomou V	9
15	Tsinghua U	22	Switzerland	55	Rosenow J	9
16	Aalto U	20	Norway	54	Schleich J	9
17	U Bonn	20	Denmark	53	Eyre N	8
18	ETH Zurich	19	Austria	44	Galvin R	8
19	U Leeds	19	Portugal	40	Gokdogan O	8
20	U Coimbra	18	Iran	39	Kaushik SC	8
21	U Cambridge	18	Brazil	38	Torriti J	8
22	Columbia U	16	Turkey	35	Baran MF	7
23	Helmholtz Association	16	Taiwan	31	Brown MA	7
24	Stanford U	16	Greece	30	Delmas MA	7
25	Xiamen U	16	Malaysia	28	Du HB	7
26	Aalborg U	15	Belgium	27	Jain RK	7
27	Loughborough U	15	South Korea	27	Liang QM	7
28	National U Singapore	15	Ireland	25	Palm J	7
29	Technical U Denmark	15	South Africa	25	Schlomann B	7
30	U Pretoria	15	Poland	22	Schmitz A	7

Abbreviations: R = rank; TP = total papers

to energy efficiency. Despite this primary focus, the journal also cited journals in other related areas including psychology, economics, management and engineering, showing the interest towards a multidisciplinary approach.

To see how the results are evolving through time, we have divided the data in two periods, namely, 2008–2012 and 2013–2017. The reason for doing so is twofold: we show both the journals more frequently cited in the first years of the journal and how these results are evolving during the last years. Table 8 presents the 30 most cited journals in each period and the global results for the whole 10 years of the journal.

Energy Policy is by far the most cited journal in *Energy Efficiency*. However, the results show that *Energy Economics* and *Energy* were the second and third most cited journals in the first 5 years of the journal, but during the last 5 years, they have lost this position in the benefit of *Energy and Buildings* and *Energy Efficiency*. Although *Energy Economics* is now the fifth most cited journal in *Energy Efficiency*, it is worth noting that many other journals in economics are becoming highly cited in *Energy Efficiency*, including *Ecological Economics*,

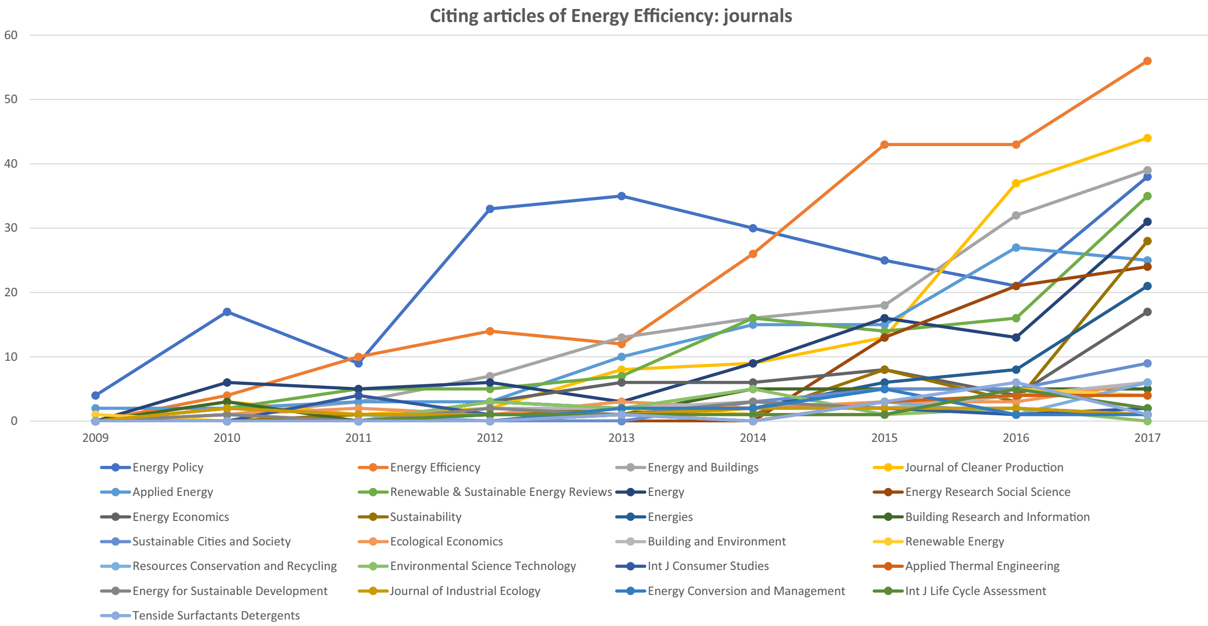

Fig. 3 Annual number of manuscripts citing *Energy Efficiency* journal

American Economic Review, and the *Review of Economics and Statistics*.

Next, we have looked into the co-citations of authors highly cited in *Energy Efficiency*. Figure 5 presents the

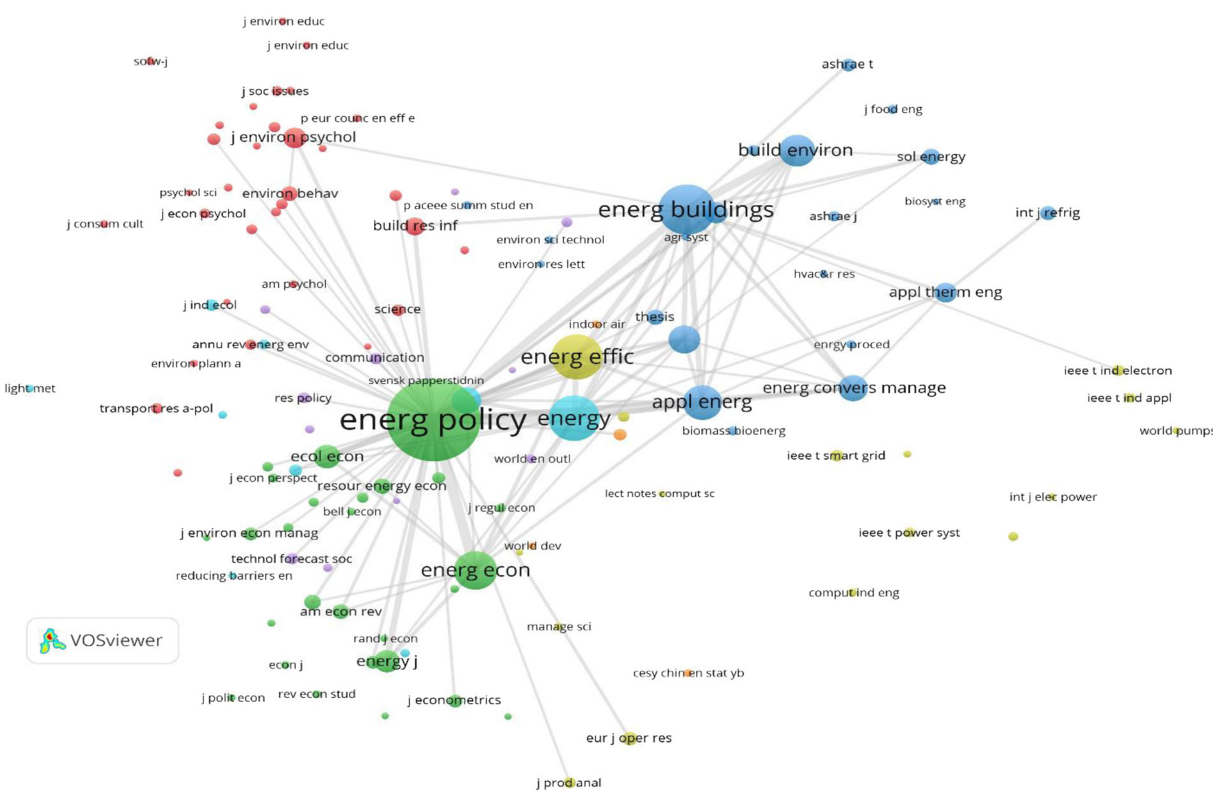

Fig. 4 Co-citation of journals in *Energy Efficiency* minimum citation threshold of 10 and 100 links

Table 8 Co-citation of journals in *Energy Efficiency*: global and temporal analysis

R	Global Journal	Cit	CLS	2008–2012 Journal	Cit	CLS	2013–2017 Journal	Cit	CLS
1	Energ Policy	1528	1028.35	Energ Policy	385	242.86	Energ Policy	1145	777.84
2	Energ Buildings	568	403.84	Energ Econ	72	64.91	Energ Buildings	518	363.41
3	Energ Effic	465	393.82	Energy	69	59.62	Energ Effic	405	341.85
4	Energy	457	402.22	Energ Effic	64	52.23	Energy	388	340.97
5	Energ Econ	326	281.24	Energ Buildings	50	39.63	Energ Econ	254	215.83
6	Appl Energ	268	246.28	Energy J	37	32.42	Appl Energ	251	229.54
7	Build Environ	229	179.85	Energ Convers Manage	29	24.01	Build Environ	211	164.1
8	Renew Sust Energ Rev	181	170.95	Ecol Econ	23	22.61	Renew Sust Energ Rev	172	162.03
9	J Clean Prod	152	135.32	J Environ Psychol	19	14.58	J Clean Prod	135	118.33
10	Energ Convers Manage	151	136.08	Build Environ	18	15.76	Energ Convers Manage	122	111.19
11	Ecol Econ	125	119.86	J Environ Econ Manag	18	15.77	Ecol Econ	102	97.17
12	Energy J	114	100.97	Appl Energ	17	16.47	Renew Energ	87	78.74
13	Renew Energ	101	91.96	J Clean Prod	17	16.73	Energy J	78	70.08
14	J Environ Psychol	92	80.94	Energy Env	15	14.92	Appl Therm Eng	77	68.4
15	Appl Therm Eng	88	77.01	Renew Energ	14	12.89	J Environ Psychol	73	64.34
16	Build Res Inf	74	68.57	Resour Energy Econ	14	13.87	Build Res Inf	64	59.43
17	Sol Energy	59	52.11	Science	14	13.35	Sol Energy	53	46.28
18	Resour Energy Econ	53	52.05	Ashrae J	12	11.14	Am Econ Rev	43	41.31
19	Am Econ Rev	50	48.29	Ashrae Tran	12	10.42	Int J Refrig	42	28.21
20	Environ Behav	49	45.38	Environ Behav	12	10.75	Resour Energy Econ	39	38.17
21	Rev Econ Stat	48	45.48	Appl Therm Eng	11	8.56	Rev Econ Stat	39	36.64
22	Int J Refrig	47	32.9	Environ Resour Econ	11	10.77	Environ Behav	37	34.16
23	Eur J Oper Res	41	35.2	World En Outl	11	6	Econometrica	32	30.29
24	J Environ Econ Manag	39	36.44	Build Res Inf	10	9.04	Eur J Oper Res	32	27.08
25	Ashrae T	36	30.28	Communication	10	3.8	IEEE T Smart Grid	31	23.1
26	Econometrica	36	34.32	Clim Policy	9	6.76	J Econometrics	31	29.46
27	J Econometrics	36	34.03	Eur J Oper Res	9	8.03	Energy Sustain Dev	30	28.65
28	Resour Conserv Recy	32	30.84	J Consum Res	9	7.87	Int J Consum Stud	28	22.62
29	Energy Sustain Dev	32	30.65	Renew Sust Energ Rev	9	8.83	IEEE T Ind Electron	28	21.83
30	Science	32	30.3	Rev Econ Stat	9	8.74	Resour Conserv Recy	27	26.02

Abbreviations: Cit = citations; CLS = citation link strength

results considering a threshold of ten citations and visualizing the 100 most representative connections.

Steve Sorrell, from the University of Sussex (UK), is the most cited author in *Energy Efficiency* followed by Beng Wah Ang, from the National University of Singapore. Interestingly, Steve Sorrell does not fall under the list of top leading authors (as shown in Table 4). Nevertheless, his work over barriers to (and more generally economics for) energy efficiency represents a key topic that many *Energy Efficiency* authors recall in their studies. Note that some of these authors have a more interdisciplinary profile as Steve Sorrell, who also connects with other areas like, e.g., economics or political science. In this context, the aim of Fig. 4 is to visualize the most cited authors in the journal independently of their specific profile that can be specialized in topics connected to energy efficiency or more general connecting with other fields. It is also worth noting that documents published by the International Energy Agency (IEA) and the European Commission are also highly cited in the journal.

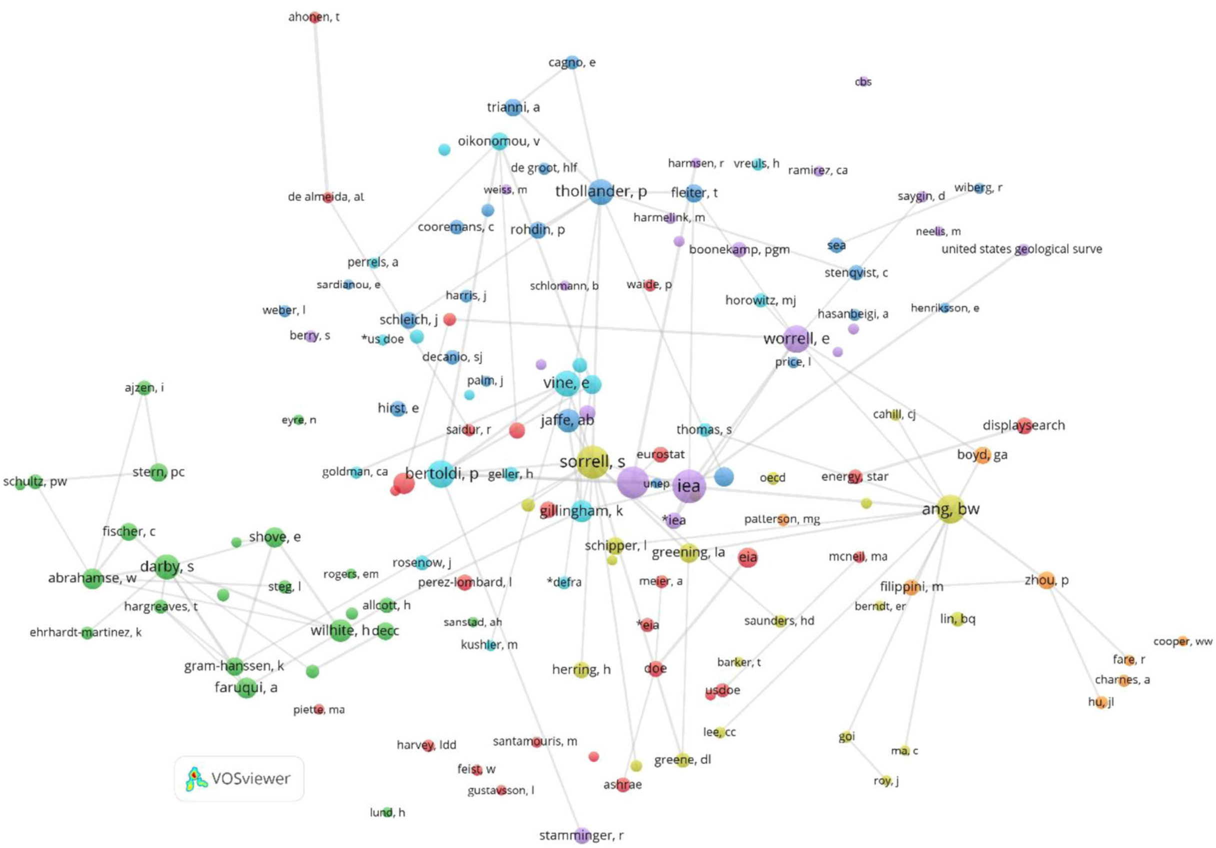

Fig. 5 Co-citation of authors in EF: minimum citation threshold of 10 and 100 links

Another interesting issue is to analyze the publications of universities in *Energy Efficiency*. For doing so, the article uses bibliographic coupling of universities (Valenzuela et al. 2017), which considers the institutions that publishes the highest number of documents in *Energy Efficiency* and connects those that cite same documents more frequently. Figure 6 visualizes the results (with a minimum threshold to appear in the graph of two documents) and shows the 100 most representative bibliographic coupling links.

The results are consistent with those of Table 5 where the University of California Berkeley is by far the most productive university in the journal. Note that institutions from the same countries or regions tend to appear close to each other. Two main reasons could offer explanation to this finding: first, the co-authorship, implying that two authors present a similar citation profile; second, it is quite common that researchers from the same region tend to work on similar specific topics becoming particularly popular in that region.

Next, we have tried to generalize these results at country level, by using bibliographic coupling of countries. It is worth noting that the analysis of countries represents the author affiliation at the time of publication in *Energy Efficiency*. In Fig. 7, we present the results considering a minimum publication threshold of two documents and the 50 strongest bibliographic coupling links.

The USA appears as the country with the highest number of published articles in *Energy Efficiency*. However, its results are not so remarkable according to the country size. In fact, Fig. 6 clearly visualizes the stronger influence played by European countries on the journal. Particularly, the results of Sweden and Netherlands, with higher figures by normalizing articles per capita, are notable.

Finally, we have analyzed the most common keywords used in the journal, which provides a general orientation of the leading topics in *Energy Efficiency*. To do this, first we have studied co-occurrence of author keywords by counting the number of times a keyword

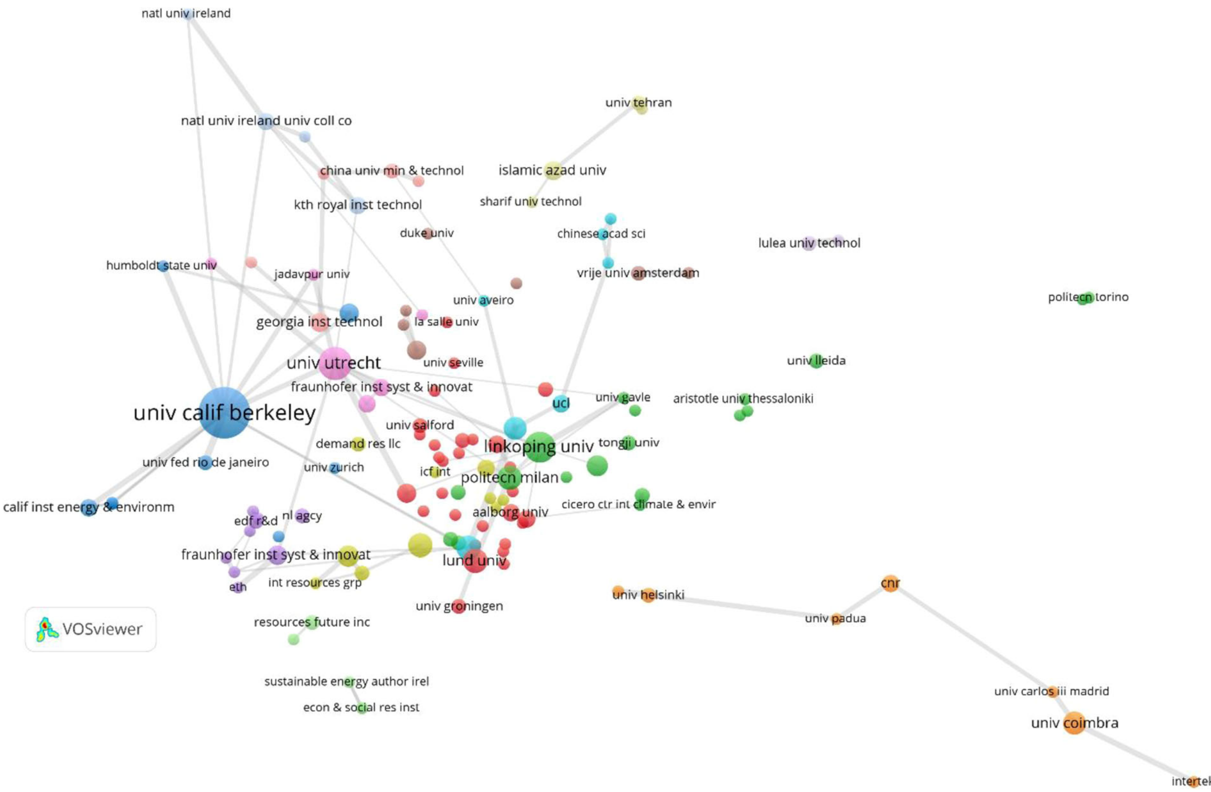

Fig. 6 Bibliographic coupling of institutions publishing in *Energy Efficiency*: minimum publication threshold of 2 documents and 100 links

appears in the list of keywords provided by the authors together with the abstract. Second, we have measured those keywords appearing more frequently in the same documents. Figure 8 presents the results considering a minimum threshold of three occurrences and the 100 strongest co-occurrence links.

Finding the keyword "energy efficiency" as the most popular one in the journal (Table 9) was somehow expected, given that it coincides with the name of the journal. But, our analysis allows to pinpoint some other keywords becoming significant in *Energy Efficiency*, including "energy savings," "energy consumption," and "demand response": these results are reasonable considering the partial overlap between them and the "energy efficiency" keyword. However, some additional interesting insights can be made. First, it is worth noting the so many connections between the keyword "energy efficiency" with others, confirming the multiple perspectives and applications covered within the journal. Second, there is a lack of a strong pattern for keywords: indeed, we can see multiple connections, but not clear clusters or independent aggregates of keywords, suggesting that, rather than pursuing consolidated research streams, the journal is addressing the energy efficiency issue throughout its multifaceted aspects. Being the journal at its early years, this finding appears as overall reasonable. Nevertheless, by further analyzing keywords over the last 5 years, two of them stepped up, namely "demand response" and "smart grid". Interestingly, firstly demand response does barely appear in the rank of first 30 keywords for 2008–2012, while ranking fourth in the 2013–2017 rank. Secondly, the keyword smart grid does not even appear in the 2008–2012 30 keywords, while ranking fifth in the 2013–2017 one. Indeed, both keywords refer to relatively appealing young topics considered as crucial for current and future energy policies (EC 2018), confirming that, for an improved energy efficiency at system level, further efforts should be paid by final users to better match the demand of power supply.

Conclusions

Energy Efficiency journal is 10 years old. To celebrate this anniversary, the present article presents,

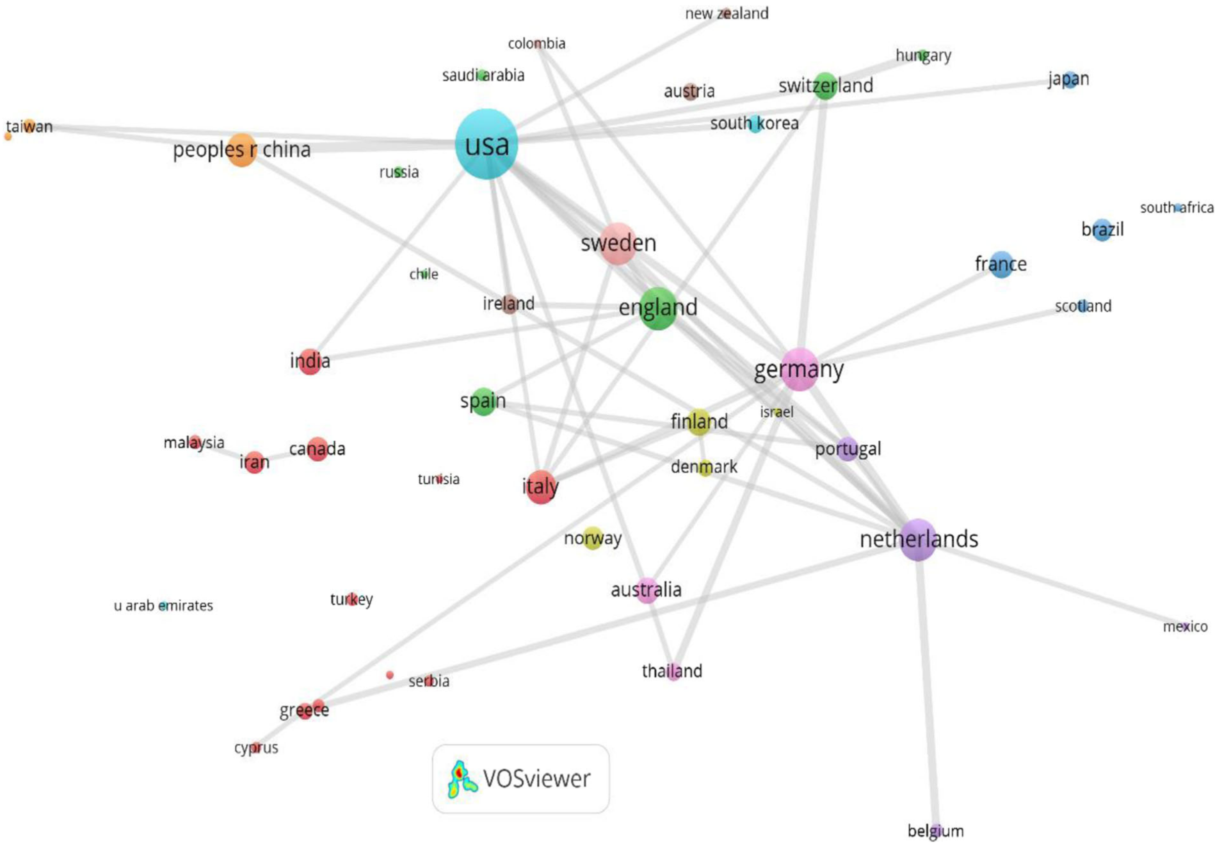

Fig. 7 Bibliographic coupling of countries publishing in *Energy Efficiency*: minimum publication threshold of 2 documents and 50 links

through a bibliometric analysis using the WoS Core Collection and Scopus databases, the leading trends occurred in the journal of this first decade. We have based our considerations on a broad set of bibliometric indicators, as well as on a visualization tool, that allowed to analyze results by creating a map of the bibliographic material, thus looking at most relevant connections between journals, topics, authors, institutions, and keywords. The main advantage of this approach is that the work offers a complete picture of the current publication and citation structure of the journal and how it is positioning in the academic debate.

Results seem to show that the *Energy Efficiency* journal is finding its room in the scientific community, tackling the multifaceted and multidisciplinary aspects of energy efficiency, from application research and innovation in various contexts, e.g., buildings or industry or transport, to "horizontal" topics, such as e.g., policy instruments, financing, smart meters, as well as behavior of final users.

Energy Efficiency aims at positioning itself at the core of the energy efficiency research and discussion, with strong connections with relevant other journals such as *Energy Policy*, *Energy and Buildings*, *Energy*, *Energy Economics*, *Applied Energy*, *Renewable and Sustainable Energy Reviews*, *Energies*, and *Journal of Cleaner Production*. Nevertheless, compared to other established and renowned journals, *Energy Efficiency* focuses on a narrower area of energy issue (i.e., energy efficiency) and explores it more in depth, by means of a multidisciplinary approach, taking benefits from consolidated disciplines such as psychology, economics, management, and engineering.

Our analysis reveals that the journal hosts contributions to a well-diversified set of institutions and countries, although predominantly influenced by European scholars, but with growing number of contributions coming from developing economies such as China, Iran, Turkey, India, and Brazil. Moreover, the bibliometric analysis shows interesting positive trends in both the number of manuscripts published per year as well as

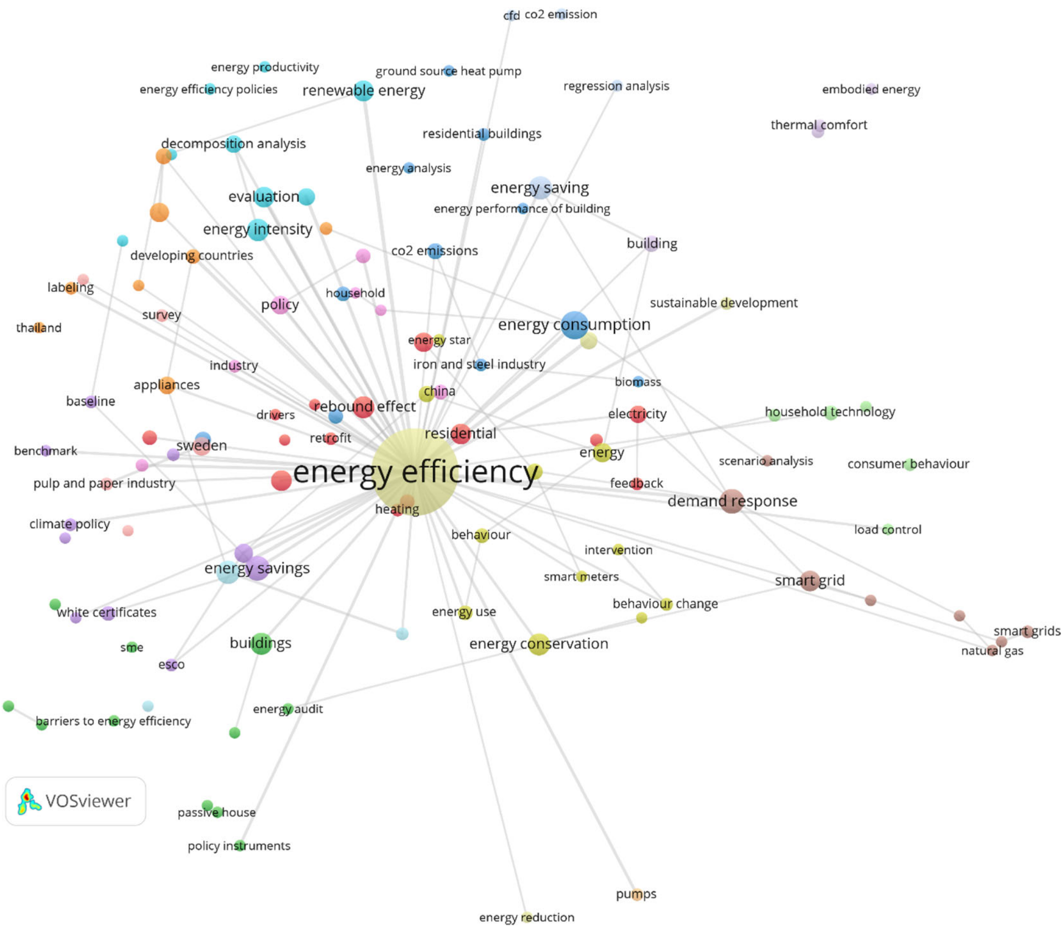

Fig. 8 Co-occurrence of author keywords in *Energy Efficiency*: minimum occurrence threshold of 3 and 100 link

annual number of citations, especially from other journals.

To conclude, some future research avenues in the field can be sketched. The study, by showing the growing linkages between *Energy Efficiency* and other relevant journals, showcases that future coordinated efforts from different disciplines (technical, economic and sociopsychological ones) could be particularly interesting and effective to address the energy efficiency challenges and contribute to sustainable development. This is particularly evident by looking at the "energy efficiency first" approach proposed by the European Commission (EC 2018): rather than promoting single-specific actions, energy efficiency is looked as a compass to guide any decision-making. More specifically, the scope is quite large, as energy efficiency should be improved at all stages of the energy chain, from generation to final consumption. Interestingly, this requires not only further knowledge on the technological issues regarding the performance of equipment, but also improved knowledge over the issues affecting the energy efficiency value chain, as well as challenges for final users, as this analysis of the *Energy Efficiency* journal shows.

Increased multidisciplinary efforts should also address the so-many benefits from energy efficiency improvement: we can note that this topic is receiving greater and greater attention by scholars and policy-makers (e.g., Nehler 2018; Nehler et al. 2018) but, in order to be pinpointed and quantified, deliberate and accurate consideration from many disciplines is of crucial importance. Related to this, future research about non-energy benefits could pave the way to further efforts in integrating energy efficiency improvements (and savings) within a carbon reduction framework, so more clearly express the contribution and leverage of energy efficiency to sustainable development and climate change mitigation, as prompted by one of the most cited manuscripts in this journal (Worrell et al. 2009).

Table 9 Co-occurrence of author keywords in *Energy Efficiency*: global and temporal analysis

Global				2008–2012			2013–2017		
R	Keyword	Occ	Co-oc	Keyword	Occ	Co-oc	Keyword	Occ	Co-oc
1	Energy efficiency	175	127	Energy efficiency	68	54	Energy efficiency	107	90
2	Energy savings	27	20	Energy savings	9	8	Energy savings	18	16
3	Energy consumption	18	13	Buildings	6	6	Energy consumption	13	11
4	Demand response	14	12	Evaluation	6	5	Demand response	11	9
5	Energy policy	13	12	Energy consumption	5	3	Smart grid	10	9
6	Buildings	11	8	Energy intensity	5	1	Energy policy	8	7
7	Energy conservation	11	8	Energy policy	5	5	Energy	7	6
8	Energy intensity	11	6	Rebound effect	5	4	Energy conservation	7	6
9	Rebound effect	11	7	Renewable energy	5	5	Residential	7	7
10	Barriers	10	10	White Certificates	5	4	Barriers	6	6
11	Evaluation	10	9	Barriers	4	4	Decomposition analysis	6	5
12	Renewable energy	10	8	Climate policy	4	4	Energy efficiency policy	6	4
13	Residential	10	9	Efficiency	4	4	Energy intensity	6	5
14	Smart Grid	10	7	Energy conservation	4	3	Industrial energy efficiency	6	5
15	Energy	9	6	Energy services	4	3	Rebound effect	6	4
16	Energy efficiency policy	9	5	Market transformation	4	3	Appliances	5	4
17	Market transformation	9	6	Policy	4	4	Buildings	5	4
18	Energy services	8	7	Sweden	4	3	CO_2 emissions	5	5
19	Policy	8	6	Behavior	3	2	Electricity	5	5
20	Sweden	8	8	Climate change	3	3	Energy management	5	4
21	Appliances	7	6	Data envelopment analysis	3	2	Household technology	5	4
22	Climate change	7	6	Decision-making	3	2	Market transformation	5	5
23	Data envelopment analysis	7	5	Demand response	3	3	Renewable energy	5	4
24	Decomposition analysis	7	6	Demand-side management	3	3	Behavior change	4	4
25	Electricity	7	5	Electricity consumption	3	3	Benchmarking	4	2
26	Building	6	5	Energy efficiency policy	3	3	Building	4	4
27	CO_2 emissions	6	5	Greenhouse gas mitigation	3	3	Climate change	4	3
28	Cost-effectiveness	6	5	Household	3	3	Commercial buildings	4	3
29	Efficiency	6	4	Industry	3	3	Cost-effectiveness	4	3
30	Electricity Consumption	6	6	Labeling	3	3	Data envelopment analysis	4	4

Abbreviations: Occ = occurrences; Co-oc = co-occurrence link strength

Furthermore, future energy systems represent another field whose success is subject to multidisciplinary support and attention from academia, research, and innovation centers. In fact, the evolution of smart grids seems so far subject to several key challenges, e.g., in Europe, such as regulatory barriers, technology maturity, and consumer engagement (Iqtiyanillham et al. 2017; Hansen and Hauge 2017). In parallel, recent research (e.g., Lund et al. 2014) is delving into new paradigms aimed to the integration of smart thermal grids into future sustainable energy systems. In both cases, as revealed from our findings, a valuable contribution, among others, could come from future research focusing on how to more effectively value energy efficiency as part of an evolving smarter grid and more sustainable energy system.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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