ResearchGate

See discussions, stats, and author profiles for this publication at: https://www.researchgate.net/publication/349003112

Evolution of Smart Grid Assessment Methods: Science Mapping and Performance Analysis

Article · December 2020

CITATIONS
0

READS
37

3 authors:

Eliseo Juan Zarate Perez
Universidade Federal Fluminense
3 PUBLICATIONS **3** CITATIONS
SEE PROFILE

Ana Motta
Universidade Federal Fluminense
15 PUBLICATIONS **14** CITATIONS
SEE PROFILE

Juan herber Grados
Universidad Nacional del Callao, El Callao
10 PUBLICATIONS **3** CITATIONS
SEE PROFILE

Some of the authors of this publication are also working on these related projects:

Energy Efficiency View project

All content following this page was uploaded by Eliseo Juan Zarate Perez on 03 February 2021.

The user has requested enhancement of the downloaded file.

International Journal of Engineering Research and Technology. ISSN 0974-3154, Volume 13, Number 12 (2020), pp. 5166-5175
© International Research Publication House. http://www.irphouse.com

Evolution of Smart Grid Assessment Methods: Science Mapping and Performance Analysis

Eliseo J. Zarate P.[1,2*], Ana. L. T. S. Da Motta[3] and Juan H. Grados G.[4]

[1]Professor, Faculty of Engineering, Universidad Privada del Norte (UPN), Peru.

[2] Ph.D. Student, Programme in Industrial Engineering Technologies, (UNED), Spain.

[3] Professor, Postgraduate Program in Civil Engineering, (UFF), Brazil.

[4] Professor, Department of Electrical and Electronic Engineering, (UNAC), Peru.

Corresponding author(ORCID: 0000-0002-3946-4924)*

Abstract

The field of research related to smart grid (SG) assessment methods is broad and fragmented owing to the contribution of the various disciplines and approaches involved. This presents difficulties in obtaining useful and unbiased information for future studies. Hence, a full review of the contributions could provide a comprehensive critical perspective. In this article, SciMAT software is used to determine the evolution of this research field through a systematic review of the literature based on 331 original research articles. In addition, hidden issues and their development in this field have been identified for the period 2009–2020 to produce strategic diagrams of the thematic evolution and performance indicators of the research field. The results show that SG assessment methods are important topics, and the research field demonstrates an evolutionary trend that has not yet reached a maturity stage in each of the SG-related research topics. The most important topics, such as electric power transmission networks and environmental impact, are highlighted, with a particular interest in the transmission of electric power, application of photovoltaic systems, and life cycle analysis.

Keywords: Assessment methods, assessment systems, environmental impact, electric power, smart grid.

I. INTRODUCTION

Electric power generation and distribution systems face several challenges and concerns originating not only from power supply shortages, but also from environmental and operational issues. They must respond to such challenges quickly and efficiently to preserve the stability and continuity of operations according to the demand requirement [1]. Therefore, recent technological advances have expanded the possibilities of using electrical grids in conjunction with smart grids (SGs) to revolutionize the way electrical energy is generated, transmitted, consumed, and distributed [2].

Emphasizing the key role of SGs in building smart energy solutions and smart cities will help achieve sustainable energy goals and social and economic development in a rapid and sustained manner [3]. However, as new technologies need to be integrated, the implementation of SGs is limited [4]. Aspects, such as the lack of a solid regulatory framework as well as the technical skills and knowledge necessary for the development of SGs, market uncertainty, the need for quality service by distributors, and technological immaturity, are considered barriers to the proper development of SGs worldwide [5], [6].

Accordingly, in the last few decades, numerous tools for SG assessment have been developed through policies related to distribution networks, significantly changing their operation and control [7]. These methods, based on a series of indicators that measure different aspects, propose a consumer-centered assessment model based on SGs [8]. Thus, the proposed methods incorporate techniques that include real-time simulation, power system-in-the-loop, power hardware-in-the-loop, controller hardware-in-the-loop, and co-simulation technologies [9]. These methods directly support the acceleration of development of electrical systems and the research on power electronic components by validating technological solutions in high-fidelity environments.

Thus, the adoption of solutions to implement SGs requires the definitions of metrics, variables, or methodologies that facilitate the understanding and development of projects of this nature. Therefore, this study aimed to conduct a bibliographic analysis of the assessment methods of SGs using a science mapping approach. Accordingly, the following specific objectives were established: (i) perform a qualitative analysis based on a systematic review and (ii) perform a quantitative review through bibliometric analysis. This study will contribute to the existing body of knowledge by highlighting the trends and patterns in the research field of SGs, establishing the relevant research topics, mapping researcher networks, and recommending areas for future study.

II. METHOD

A dual integrated analysis was conducted to achieve the objectives of this study. It consists of (i) a systematic literature review (SLR) of the bibliographic records on the assessment methods adopted in the research field of SGs and (ii) a review based on the bibliometric analysis of the selected records.

II.I Systematic literature review (SLR)

A procedure that defines the search strategy, exclusion criteria, and data extraction methods to synthesize the results was conducted to generate the SLR. Several authors have

implemented an SLR in their research considering different stages, with the aim of developing a transparent and replicable scientific research process [10], [11], [12], [13], [14]. The aim of this approach is to avoid any possibility of bias or prejudice that may arise from the application of pre-established criteria [15]. In this article, the methodological sequence of an SLR is based on [16], developed in the following stages, as presented in Fig 1.

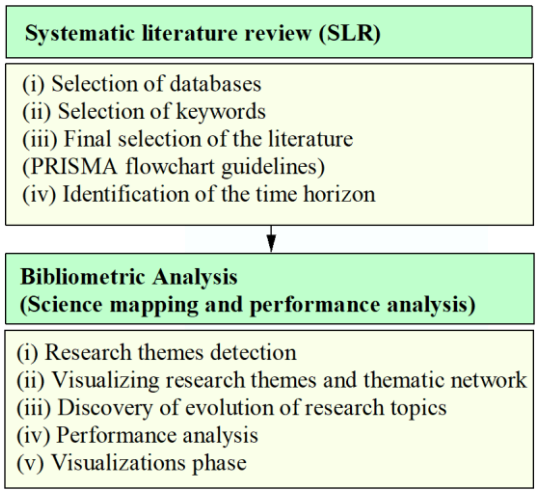

Fig. 1. Methodological sequence to identify the evolution of SG assessment methods

(i) Selection of databases: The Elsevier database of abstracts and citations (Scopus) was selected, as it contains several high-impact international scientific and technical publications relevant to the topic and problem addressed.

(ii) Selection of keywords: The keywords have been selected to include only those studies that are related to the topic. The search was conducted using the "Title / Abstract / Keyword" field using the operators inclusive AND, OR, and * (to guarantee the search generalization). The keywords used in the SLR are presented in Table 1.

Table 1. Keywords used in the SLR Search

Operator	Keywords
OR	"assessment methods," "assessment tools," "assessment systems," "indicators*," "environmental impact," "social impact" and "economic impact."
AND	"smart grid" OR "smartgrids*"

iii) Final selection of the literature: The documents were selected according to relevance, that is, based on whether they contain the data necessary to address the subject dealt with in the SLR, using the guidelines of the PRISMA flow diagram [17].

v) Identification of the time horizon: Once the relevant documents were selected, the time horizon and periods were selected for analysis. They were established according to several criteria, such as the number of records, relevant items, and turning points in the research field [18].

II.II Bibliometric Analysis

It was conducted using SciMAT software (science mapping analysis tool), which is a free scientific mapping tool that allows the analysis of the social, intellectual, and conceptual evolution in a scientific field [19]. SciMAT has been successfully applied in multiple areas, such as computer science, engineering, business and management, and environmental science [20], [21], [16], [22], [23], [24], [25].

This tool uses a series of scientific publications to build a knowledge base in which the identity of each publication is stored. It is based on the analysis of joint words and the h-index. Similarly, it incorporates methods, algorithms, and measures for all the steps of the general scientific mapping workflow, from pre-processing to the visualization of results [19]. The analysis method was established in the following stages.

i) Research theme detection: SciMAT applies a co-word analysis to the raw data of all the documents published in the research field. The tool then uses an equivalence index, which builds a standardized bibliometric network of keywords, and finally applies the simple core algorithm to group keywords into topics.

ii) Visualizing research themes and thematic networks: In this stage, the detected themes are shown by means of two-dimensional strategic diagrams depending on the degree of interaction between research topics, as shown in Fig 2. In addition, the tool considers the internal force value of the research topic.

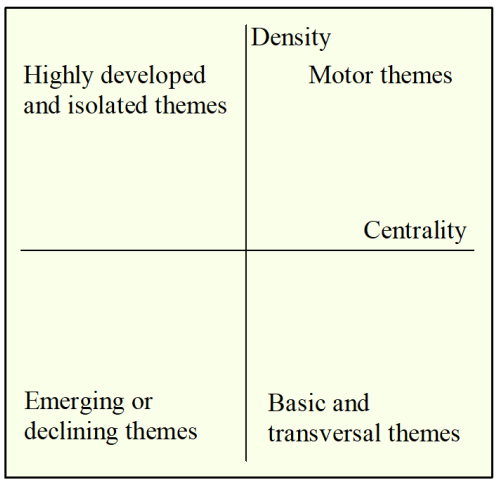

Fig. 2. Visualizing research themes and thematic network

Motor themes: They are located in the upper right quadrant in Fig 2, are well developed, and are important to the structure of the research field.

Highly developed and isolated themes: They are located in the upper left quadrant in Fig 2; they are well developed but are of little importance to the field of research.

Emerging or declining themes: They are located in the lower left quadrant in Fig 2; they are poorly developed and do not have much importance in the field of research.

Basic and transversal themes: They are located in the lower right quadrant in Fig 2; they represent important topics in the field of research, but they are not yet well developed.

As a complement to the strategy diagrams, thematic networks show the relationship of each theme of these diagrams with the keywords and their interconnections. Each thematic network is tagged with the name of the most significant keyword in the topic. Here, several keywords are interconnected, where the size of the circle is proportional to the number of documents corresponding to each keyword, and the thickness of the link between two circles is proportional to the equivalence index. Fig 3 shows an example of a thematic network.

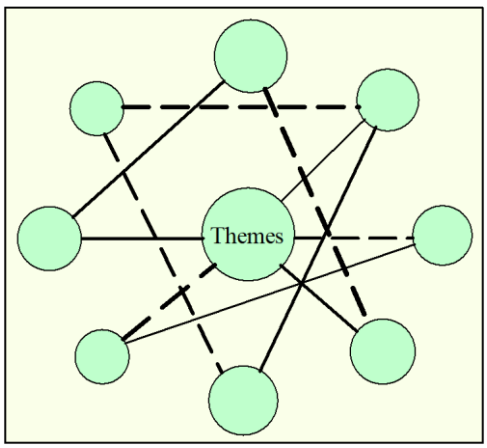

Fig. 3. Example of thematic network

iii) Discovery of the evolution of research topics: At this stage, the evolving areas of the research field, and their origins and interrelationships are detected and analyzed. The inclusion index [26] is used to detect conceptual links between research topics in different periods and to measure the strength of the association between them. This analysis is represented by two graphs:

Overlay graph: The horizontal arrow represents the number of elements shared by both time periods, as shown in Fig 4a. The top entry arrow represents the number of new items in period 2, the top exit arrow represents the items displayed in period 1 but not in period 2, and so on, for the n periods, as established for the analysis.

Evolution map: The solid lines indicate that the related topics share a name, that is, both topics have the same name, or the name of one of the topics is part of another, as shown in Fig 4b. Similarly, a dotted line indicates that the topics share elements that are not necessarily the name of the topic; however, there is a conceptual relationship between the topics. Finally, the thickness of the line is proportional to the inclusion index, and the size of the circle is proportional to the number of documents associated with each topic.

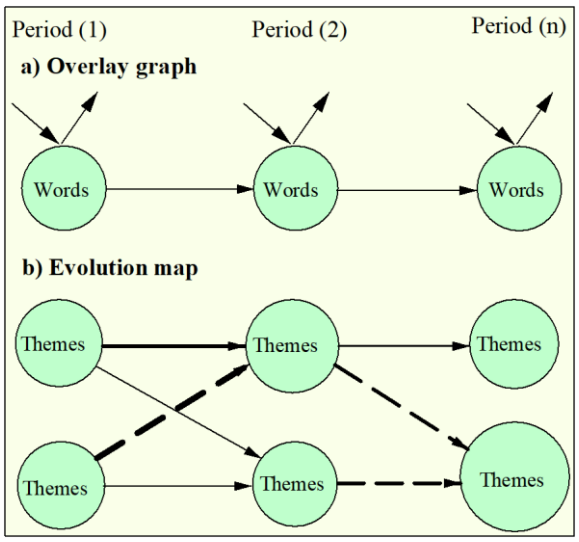

Fig. 4. Example of evolution of research topics

iv) Performance analysis: This analysis qualitatively and quantitatively measures the contribution of the research topics to the entire field through bibliometric measures, such as the number of published documents, the number of citations, and different variants of the h-index.

V) Visualization phase: Following the science mapping workflow, visualization techniques are used to produce a scientific map and display the results of the different analyses.

III. RESULT

III.I Systematic literature review (SLR)

i) Final selection of literature

Here, 858 records of bibliographic information were obtained from the selected database. A total of 491 records were excluded by applying the exclusion criteria, such as the type of document and the relationship with the research field. A full text review of the remaining 367 records was performed, and 36 additional records were excluded because they did not cover the topics included in this review. Thus, 331 relevant documents remained for the bibliometric study.

ii) Identification of the time horizon

The time horizon was determined based on the main milestones and inflection points in the evolution of the methods of assessment of SGs. The first attempts to propose methods for the evaluation of operative systems were undertaken in the 2000s [27]. However, the time horizon used in this study was from 2009 to 2020, considering the number of documents selected and the relevant milestones, to analyze the trends in publication patterns. The studies are subdivided into the following periods: 2009 to 2016, 2017 to 2018, and 2019 to 2020.

The first SG reports obtained date back to the 2000s, coinciding with Directive 2010/31/EU of the European Parliament and of the Council of May 19, 2010, on the energy efficiency of buildings [28], modified in 2018 by Directive (EU) 2018/844 to accelerate the economically profitable renovation of existing buildings and the promotion of smart technologies in buildings. Thus, there was a marked increase due to concern for the evaluation of sustainable constructions, which in turn was reflected in an increase in research in this field.

iii) Articles published and cited by year

Fig 5 shows the distribution of 331 publications and a total of 6929 citations in the period from 2009 to 2020. An irregular distribution is observed in the number of articles published each year, with an increasing trend year upon year. This demonstrates the attention paid in recent years to assessment methods that have become a vital part of SG research. Similarly, the registry of the cited articles shows a considerable impact in 2010 of the topics addressed through the citations made.

Notably, in the period 2009–2010, only six articles were published, and 1133 citations were achieved, with 945 citations for one of the articles alone. The most cited article corresponds to a document published in 2010 by *IEEE Transactions on Industrial Electronics* [29], which deals with the opportunities and challenges related to the application of wireless sensor networks in SGs. The second most cited article was published by *Energy Policy* [30], which deals with the involvement of users in the development of a low-carbon electricity economy through SGs. Table 2 includes the five most frequently cited articles, the name of the journal, and the year of publication. Thus, the main publications that contribute to the research field are displayed.

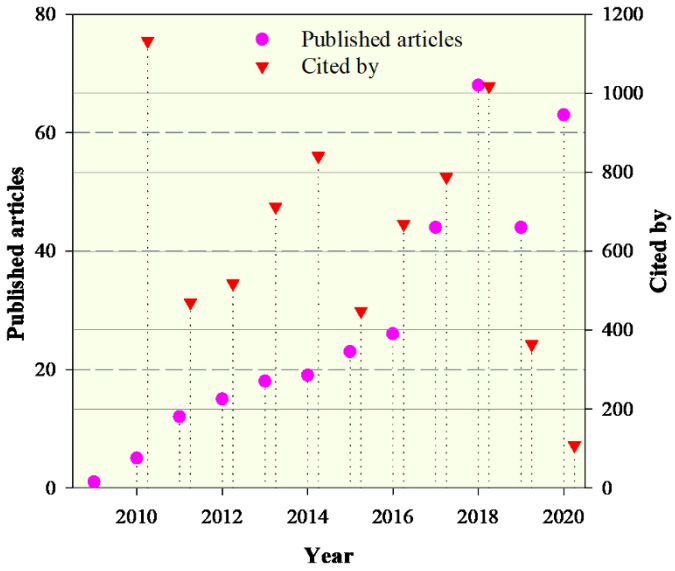

Fig. 5. Articles published and cited by year

Table 2. Main Articles that Contribute to the Research Field

Authors	Title	Year	Source title	Cited by
Gungor V.C., Lu B., Hancke G.P [29].	Opportunities and challenges of wireless sensor networks in smart grid	2010	*IEEE Transactions on Industrial Electronics*	945
Verbong G.P.J., Beemsterboer S., Sengers F [30].	Smart grids or smart users? Involving users in developing a low carbon electricity economy	2013	*Energy Policy*	201
El-Hawary M.E [31].	The smart grid - State-of-the-art and future trends	2014	*Electric Power Components and Systems*	173
Ortega-Vazquez M.A., Bouffard F., Silva V [32].	Electric vehicle aggregator/system operator coordination for charging scheduling and services procurement	2013	*IEEE Transactions on Power Systems*	155
Siano P., Sarno D [33].	Assessing the benefits of residential demand response in a real time distribution energy market	2016	*Applied Energy*	149

Table 3. Journals with the Greatest Impact by the Number of Citations

Journal / Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Applied Energy				56	273	141	165	278	278	106	16	1313
IEEE Transactions on Industrial Electronics	945	147							31			1123
Energy					119	21	54	159	25	19	16	413
Energy Policy		20	129	201				14			1	365
Renewable Energy						41		26	139	54	6	266
IEEE Transactions on Power Systems				155			65		3		1	224

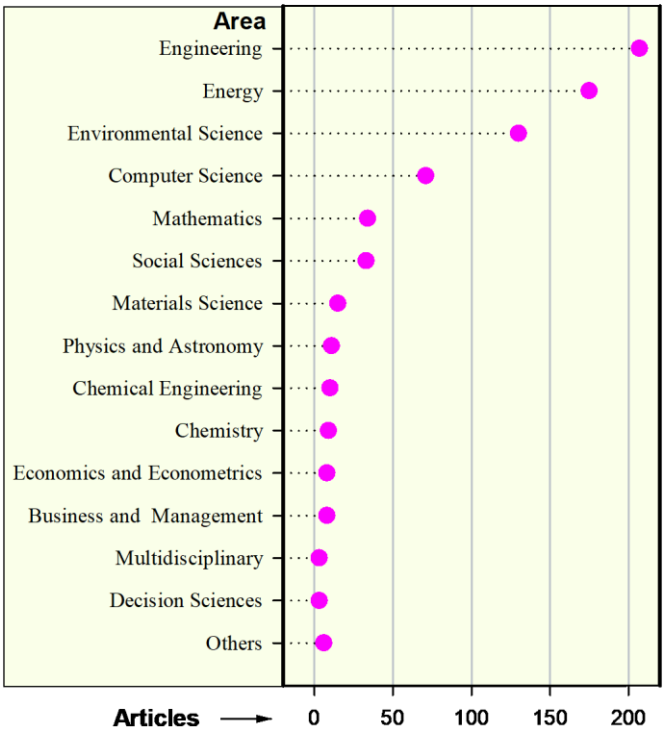

Fig. 6. Articles by areas of contribution to the SG field

Similarly, the study identified 147 journals, most of which focus on energy policies and energy efficiency in environmentally sustainable buildings and cities. The journals with the greatest impact by the number of citations are presented in Table 3. Here, it can be observed that *Applied Energy* cited by 1313 articles and *IEEE Transactions on Industrial Electronics* cited by 1123 articles lead in this indicator. Finally, within the areas addressed, the engineering field leads in the techniques presented in the application to SGs, followed by energy and environmental science, based on the documents selected for the study. The areas addressed are presented in Fig 6.

III. II Bibliometric Analysis

i) Research themes detection and performance analysis

Strategic diagrams were generated to analyze the changes over time, and they are shown for each of the periods considered for analysis (2009–2016, 2017–2018, and 2019–2020). Table 4 lists the performance measures obtained for each topic and period in terms of the number of documents, h-index, and centrality and density values. It is observed that the "electric power transmission networks" and "smart power grids" clusters are the topics with the highest h-index, that is, equal to 18 for both cases.

Table 4. Research Themes Detection and Performance Analysis by Period

Cluster	Nº documents	Nº citations	Centrality	Density	h-index
Period 1 (2009–2016)					
Energy-management-systems	7	349	57.9	43.33	6
Environmental-impact	36	1244	231.83	72.46	17
Smart-power-grids	38	1549	315.11	88.43	18
Smartgrid	30	2217	247.36	91.67	16
Period 2 (2017–2018)					
Greenhouse-gas-emission	6	128	16.67	61.11	5
Buildings	4	112	67	51.43	3
Energy-storage	15	356	128.82	67.42	12
Electric-power-transmission-networks	39	768	287.37	99.1	18
Environmental-impact	29	596	333.38	95.15	15
Smartgrid	35	661	556.95	117.38	16
Period 3 (2019–2020)					
Cost	7	40	87.22	32.38	2
Life-cycle	15	145	206.59	94.59	5
Photovoltaic-system	22	100	251.71	87.32	6
Electric-power-transmission-networks	46	173	253.95	130.94	7
Environmental-impact	26	176	428.18	99.57	6
Smartgrid	32	225	428.55	91.67	7

ii) Visualizing research themes

First period (2009–2016)

According to the strategic diagram, presented in Fig 7, four research topics can be observed in the 120 articles selected in this period: (i) energy management systems, (ii) environmental impact, (iii) smart power grids, and (iv) smart grids. Of these, (iii) and (iv) are considered highly developed and important topics in this field of research. Furthermore, (i) is considered an emerging or declining issue because it is not well developed and is not very important in this field. Finally, a neutral topic (ii) is presented for the research field (centrality and density near zero).

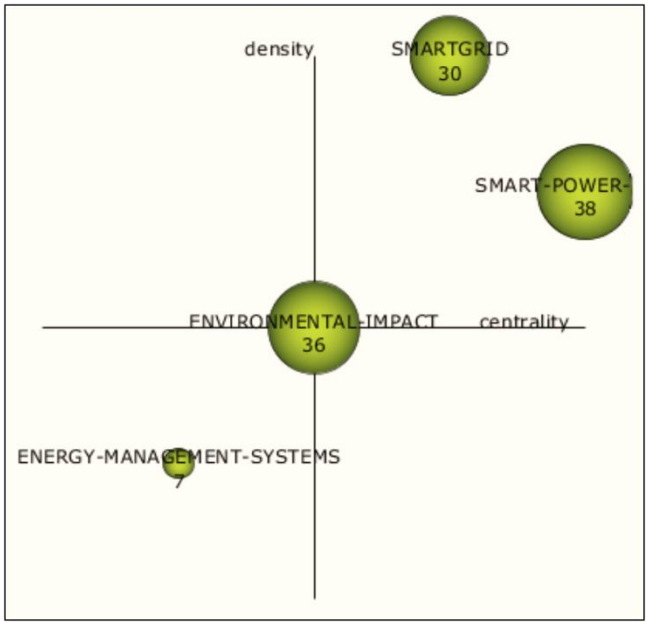

Fig. 7. Research themes to period (2009–2016)

The performance analysis for each topic, as shown in Table 4, complements the information provided by the diagram. The topic with the highest performance measure is the smart grids. This topic has a high rate of impact and has 2217 citations from 30 documents with an h-index of 16. However, "smart-power-grids," which has 1548 citations from 38 published documents, has a higher h-index of 18, as can be observed in the same table.

Second period (2017–2018)

According to the strategic diagram, presented in Fig 8, of the 106 articles selected in this period, six research topics can be observed: (i) buildings, (ii) electric power transmission networks, (iii) energy storage, (iv) environmental impact, (v) greenhouse gas emission, and (vi) smart grids. Three of these are considered important and driving themes for this research area (ii, iv, and vi), two are considered emerging or declining themes (i and v), and one is considered a neutral theme within the research field (iii). In the same way as in the previous period, no highly developed topic was presented independently.

According to the performance measures shown in Table 4, the smart grids topic is notable for having a high impact rate (661 citations) and an h-index of 16 from 35 articles. However, the topic of electric power transmission networks presents an h-index of 18 with 768 citations from 39 published articles. Within the theme of smart grids, photovoltaic systems, power plants, economic and social effects, photovoltaic cells, solar power generation, solar power, life cycle analysis, renewable resource, and energy consumption are evaluated.

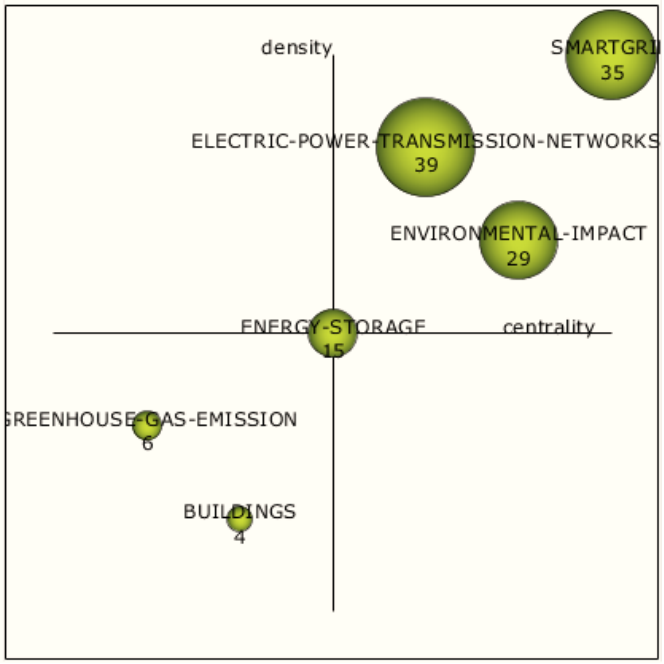

Fig. 8. Research themes to period (2017–2018)

In the topic of electric power transmission networks, the energy market, power grids, electricity generation, benchmarking, performance indicators, advanced metering infrastructures, electric utilities, economic analysis, electric load dispatching, and power quality are analyzed.

Third period (2019–2020)

According to the strategic diagram presented in Fig 9, of the 106 works selected in this period, six research topics can be observed: (i) cost, (ii) electric power transmission networks, (iii) environmental impact, (iv) life cycle, (v) photovoltaic system, and (vi) smart grids. Among these, (ii) and (iii) are considered motor, well-developed, and important themes for the structure of the research field. Similarly, one theme is considered an emerging or declining theme (i) and, finally, two themes are considered important for the scientific field but are not well developed in this period (v and vi).

According to the performance measures, the topic electric power transmission networks can be highlighted from 36 articles and 173 citations with an h-index of 7. On the other hand, the topic environmental impact presented 176 citations from 26 published articles with an h-index of 6. Thus, these research topics demonstrated a high impact and an h-index score higher than those of the other topics. Similarly, the smart grids topic is not very developed, but it is considered very

important in this field of research because it presents 32 published documents and 225 citations with an h-index of 7.

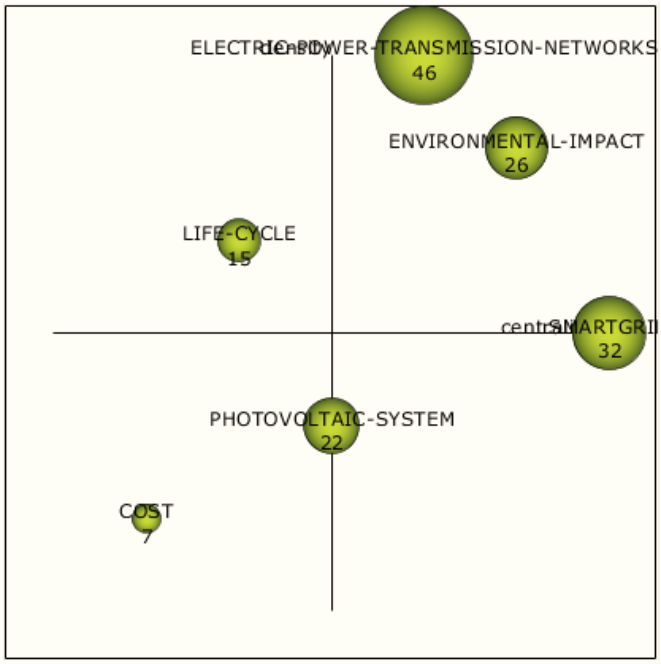

Fig. 9. Research themes to period (2019–2020)

iii) Thematic network

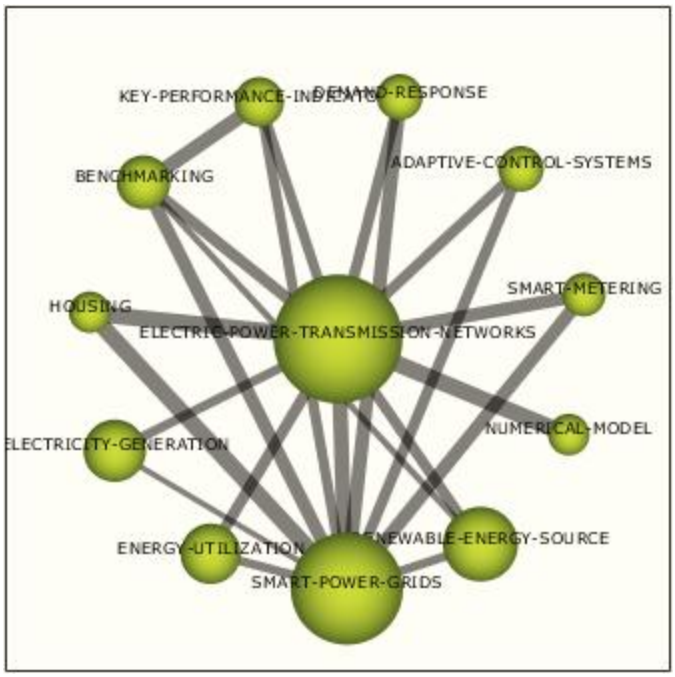

Fig. 10. Thematic network for electric power transmission networks

The electric power transmission networks theme of the last period is notable as one of the most characteristic themes if analyzed from the perspective of its thematic network. Thus, in Fig 10, it can be observed that this issue, already consolidated in the last period, is closely linked to keywords, such as numerical model, renewable energy source, smart power grids, energy utilization, electricity generation, housing, benchmarking, key performance indicators, demand response, adaptive control systems, and smart metering.

All these keywords are closely related to each other and, in the last two years, they have been the subject of numerous studies. This indicates that the field of research is progressing toward the evaluation of the transmission of electrical energy networks, with an emphasis on the study of renewable energy sources and energy use in buildings, key performance indicators, response to demand, adaptive control systems, and smart energy metering.

iv) Discovery of evolution of research topics

A systematic review of the literature showed that several authors are concerned with the research field of assessment methods in SGs. However, the strategic diagrams reflect the interest of the scientific community in certain key issues, in parallel with the development of the SG concept. The results are shown in Fig 11a for the number of keywords per period and their evolution as well as the number of incoming-outgoing keywords and the percentage of keywords that are retained from one period to the next. It is shown that between 2009–2016 and 2017–2018, the number of keywords decreased slightly from 1,333 to 1294. Specifically, 14% (326 keywords) remained in the second period, and 988 were added, yielding a total of 1294 keywords.

In the third period, 356 keywords from the previous period were maintained or passed to this period, that is, 16%. This includes 873 new keywords, for a total of 1,229 keywords. These results indicate that the number of new and transitional keywords is high, but also that the number of shared keywords has increased for successive periods. Therefore, the increasing thematic diversity of the research field of SG assessment techniques and the fact that keywords reappear with greater force in subsequent periods could be indicative that this relatively new research field is consolidating gradually.

Fig 11b shows the thematic evolution of the research field through the analysis of the origins and interrelationships of the themes. The thickness of the lines represents the strength of the association, as measured by the inclusion index. If the graph is analyzed from the point of view of the number of documents, electric power transmission networks, environmental impact, and smart grids are the topics with the highest number of documents published for the three periods evaluated.

In the early years, the review shows concern for the environmental impact generated using conventional electrical energy, also considering the management aspects of electrical energy systems. For the second period, energy storage, energy transmission systems, and green energy concepts are considered, in addition to environmental impact and smart energy grids. Finally, in addition to the topics mentioned, research interest has focused on the transmission of electrical energy networks, photovoltaic systems, and the life cycle for the last period evaluated.

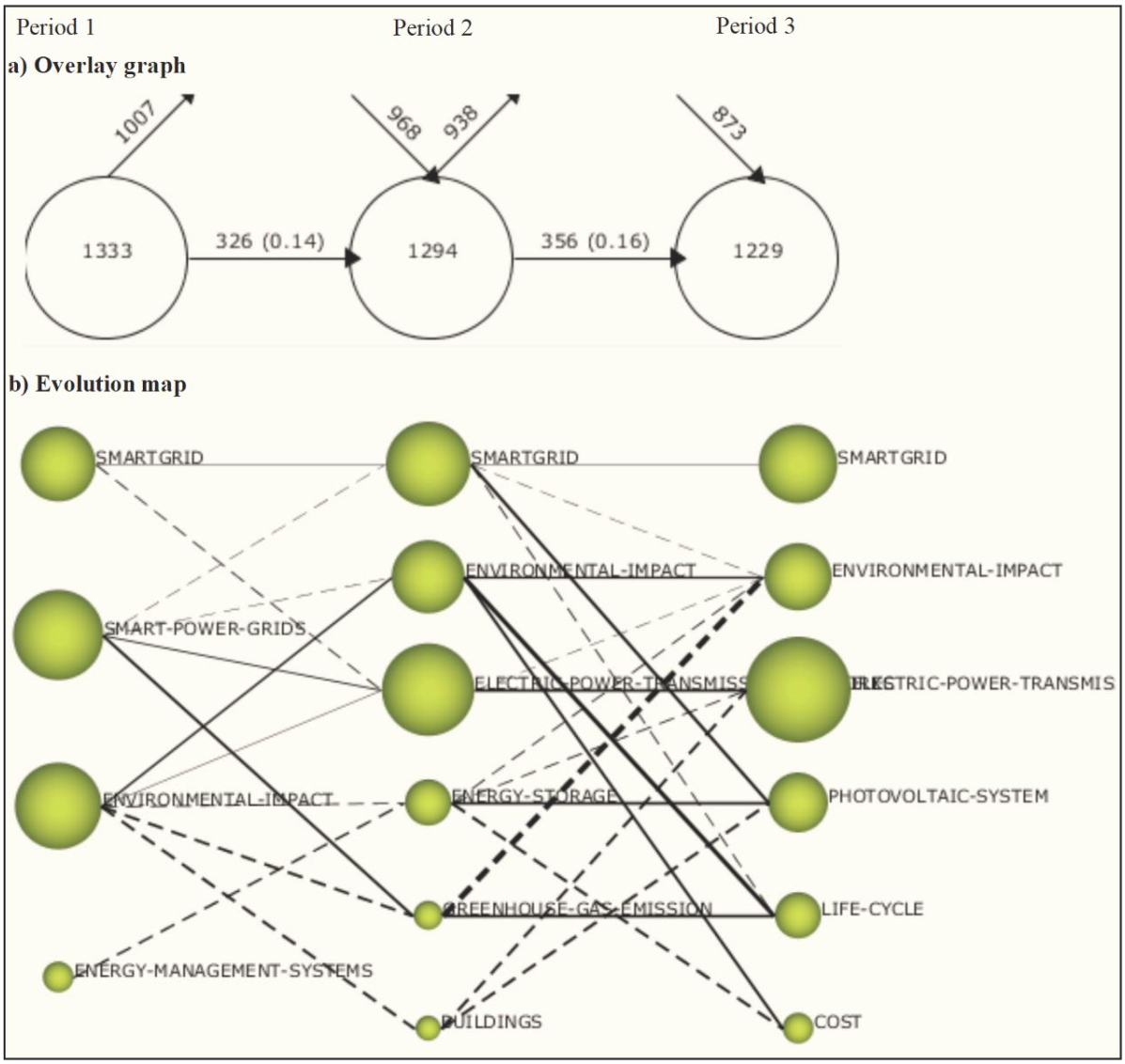

Fig. 11. Overlay and evolution map of research topics

IV. CONCLUSION

The systematic review of the literature presented is based on the use of SciMAT for the bibliometric analysis of the evolution of the selected research field between 2009 and 2020, using the publications available through the Scopus database. Trends were analyzed, considering a general vision and a more specific analysis of three different time intervals during the period under analysis (2009–2016, 2017–2018, and 2019–2020).

Analysis has shown that SG assessment methods are important topics, with a gradual increase in the number of studies on these topics published in international journals starting in 2016. The period-overlay graphs show two important fields of study: i) several new and transient keywords between sub-periods, a sign that this is a constantly evolving field of research that has not yet reached a stage of maturity; and ii) an evolutionary trend in each of the research topics in the analyzed field.

Strategic diagrams and performance analysis by period also show that emerging studies focus on the inclusion of environmental aspects and new energy sources. In the early years, there is an apparent concern about the environmental impact generated using conventional electrical energy, emphasizing the management aspects of electrical energy systems.

For the intermediate period, energy storage, energy transmission systems, and green energy concepts are considered, in addition to the environmental impact within the SG. In recent years, research interest has focused on the transmission of electric power networks, photovoltaic systems, and the life cycle. In addition, parallel interest has been maintained in the concepts of green energy and environmental impact within the SG.

This is evidently reflected in the final period, where smart grids are the basic and transversal theme, having considerable importance in the field of research. The smart grids theme involves photovoltaic system, power plant, economic and

social effects, photovoltaic cells, solar power generation, life cycle analysis, renewable resource, and energy consumption.

Finally, the most important topic for research on electric power transmission networks involves themes, such as energy market, power grids, electricity generation, benchmarking, performance indicators, advanced metering infrastructures, electric utilities, economic analysis, electric load dispatching, and power quality. Next, the second most important topic for this field of study is environmental impact. The latter involves themes, such as carbon emissions, energy market, alternative energy, gas emissions, economic and social effects, electric power generation, greenhouse gas, emission control, and environmental technology.

ACKNOWLEDGMENT

The authors would like to thank the support in part by the Universidad Privada del Norte (UPN), for their assistance in this study.

REFERENCES

[1] F. Yanine, A. Sanchez-Squella, A. Barrueto, F. Cordova, and S. K. Sahoo, "Engineering Sustainable Energy Systems: How Reactive and Predictive Homeostatic Control Can Prepare Electric Power Systems for Environmental Challenges," in *Procedia Computer Science*, Jan. 2017, vol. 122, pp. 439–446, doi: 10.1016/j.procs.2017.11.391.

[2] E. J. Zarate, M. Palumbo, A. L. T. Motta, and J. H. Grados, "FORECASTING PHOTOVOLTAIC POWER USING BAGGING FEED-FORWARD NEURAL NETWORK," *www.tjprc.org SCOPUS Indexed Journal editor@tjprc.org*, vol. 10, pp. 12479–12488, Jun. 2020.

[3] S. Zhao, Q. Xiao, and T. Xu, "Development path and case analysis of intelligent energy in intelligent city construction," in *Proceedings - 2020 International Conference on Urban Engineering and Management Science, ICUEMS 2020*, Apr. 2020, pp. 18–23, doi: 10.1109/ICUEMS50872.2020.00013.

[4] E. J. Z. Perez, M. P. Fernández, and A. L. T. S. da Motta, "Performance Analysis of Bagging Feed-Forward Neural Network for Forecasting Building Energy Demand," *Curr. J. Appl. Sci. Technol.*, vol. 30, no. 2, pp. 1–12, Oct. 2018, doi: 10.9734/CJAST/2018/44836.

[5] P. K. Poptawski and K. Szczypiorski, "Blockchain-Based Smart Contracts for Sustainable Power Investments," in *Proceedings of the 2nd World Conference on Smart Trends in Systems, Security and Sustainability, WorldS4 2018*, Jan. 2019, pp. 36–43, doi: 10.1109/WorldS4.2018.8611577.

[6] X. Leng, G. Chen, J. Bai, and J. Zhang, "General Design of Smart Grid Monitoring Operation Big Data Analysis System," *Dianli Xitong Zidonghua/Automation Electr. Power Syst.*, vol. 42, no. 12, pp. 160–166, Jul. 2018, doi: 10.7500/AEPS20170920002.

[7] D. X. Morales, Y. Besanger, S. Sami, and C. Alvarez Bel, "Assessment of the impact of intelligent DSM methods in the Galapagos Islands toward a Smart Grid," *Electr. Power Syst. Res.*, vol. 146, pp. 308–320, May 2017, doi: 10.1016/j.epsr.2017.02.003.

[8] S. Wang, L. Liu, L. Wu, and G. Zhao, "Consumer-Centric Spatiotemporal Reliability Assessment and Compensation Model with Sensitive Component Analysis in Smart Grid," *IEEE Trans. Power Syst.*, vol. 33, no. 2, pp. 2155–2164, Mar. 2018, doi: 10.1109/TPWRS.2017.2723800.

[9] J. Montoya *et al.*, "Advanced Laboratory Testing Methods Using Real-Time Simulation and Hardware-in-the-Loop Techniques: A Survey of Smart Grid International Research Facility Network Activities," *Energies*, vol. 13, no. 12, p. 3267, Jun. 2020, doi: 10.3390/en13123267.

[10] P. Savaget, M. Geissdoerfer, A. Kharrazi, and S. Evans, "The theoretical foundations of sociotechnical systems change for sustainability: A systematic literature review," *J. Clean. Prod.*, vol. 206, pp. 878–892, Jan. 2019, doi: 10.1016/j.jclepro.2018.09.208.

[11] A. El Howati and A. Tappuni, "Systematic review of the changing pattern of the oral manifestations of HIV," *J. Investig. Clin. Dent.*, vol. 9, no. 4, p. e12351, Nov. 2018, doi: 10.1111/jicd.12351.

[12] L. Muduli, D. P. Mishra, and P. K. Jana, "Application of wireless sensor network for environmental monitoring in underground coal mines: A systematic review," *Journal of Network and Computer Applications*, vol. 106. Academic Press, pp. 48–67, Mar. 2018, doi: 10.1016/j.jnca.2017.12.022.

[13] A. Fallah, M. Vafaei, and S. C. Alih, "A Review of Seismic Response of Precast Structures," *Int. J. Eng. Res. Technol.*, vol. 13, no. 10, pp. 2694–2705, 2020, doi: 10.37624/IJERT/13.10.2020.2694-2705.

[14] S. Bairavel and M. Krishnamurthy, "User Preference and Reviews Analysis with Neural Networks for Travel Recommender Systems," 2020. Accessed: Oct. 27, 2020. [Online]. Available: http://www.irphouse.com1896.

[15] C. Chen, "Science Mapping: A Systematic Review of the Literature," *J. Data Inf. Sci.*, vol. 2, no. 2, pp. 1–40, Mar. 2017, doi: 10.1515/jdis-2017-0006.

[16] C. Díaz-López, M. Carpio, M. Martín-Morales, and M. Zamorano, "Analysis of the scientific evolution of sustainable building assessment methods," *Sustain. Cities Soc.*, vol. 49, p. 101610, Aug. 2019, doi: 10.1016/j.scs.2019.101610.

[17] D. Pati and L. N. Lorusso, "How to Write a Systematic Review of the Literature," *Heal. Environ. Res. Des. J.*, vol. 11, no. 1, pp. 15–30, Jan. 2018, doi: 10.1177/1937586717747384.

[18] D. Moher, A. Liberati, J. Tetzlaff, and D. G. Altman, "Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement," *PLoS Med.*, vol. 6, no. 7, p. e1000097, Jul. 2009, doi:

10.1371/journal.pmed.1000097.

[19] M. J. Cobo, A. G. Lõpez-Herrera, E. Herrera-Viedma, and F. Herrera, "SciMAT: A new science mapping analysis software tool," *J. Am. Soc. Inf. Sci. Technol.*, vol. 63, no. 8, pp. 1609–1630, Aug. 2012, doi: 10.1002/asi.22688.

[20] J. R. López-Robles, M. J. Cobo, N. K. Gamboa-Rosales, and E. Herrera-Viedma, "Mapping the intellectual structure of the international journal of computers communications and control: A content analysis from 2015 to 2019," in *Advances in Intelligent Systems and Computing*, 2021, vol. 1243 AISC, pp. 296–303, doi: 10.1007/978-3-030-53651-0_25.

[21] J. R. López-Robles, J. R. Otegi-Olaso, I. Porto-Gomez, H. Gamboa-Rosales, and N. K. Gamboa-Rosales, "Understanding the intellectual structure and evolution of Competitive Intelligence: a bibliometric analysis from 1984 to 2017," *Technol. Anal. Strateg. Manag.*, vol. 32, no. 5, pp. 604–619, May 2020, doi: 10.1080/09537325.2019.1686136.

[22] M. J. Cobo, B. Jürgens, V. Herrero-Solana, M. A. Martínez, and E. Herrera-Viedma, "Industry 4.0: A perspective based on bibliometric analysis," in *Procedia Computer Science*, Jan. 2018, vol. 139, pp. 364–371, doi: 10.1016/j.procs.2018.10.278.

[23] J. R. López-Robles, J. R. Otegi-Olaso, I. Porto Gomez, N. K. Gamboa-Rosales, H. Gamboa-Rosales, and H. Robles-Berumen, "Bibliometric network analysis to identify the intellectual structure and evolution of the big data research field," in *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, Nov. 2018, vol. 11315 LNCS, pp. 113–120, doi: 10.1007/978-3-030-03496-2_13.

[24] A. Samia, M. M. Djamel, and B. Samira, "Proposal of a flexible and universal survey generator for a Business Intelligence," in *2018 6th International Conference on Control Engineering and Information Technology, CEIT 2018*, Oct. 2018, doi: 10.1109/CEIT.2018.8751913.

[25] Y. Zhang, W. Hua, and S. Yuan, "Mapping the scientific research on open data: A bibliometric review," *Learn. Publ.*, vol. 31, no. 2, pp. 95–106, Apr. 2018, doi: 10.1002/leap.1110.

[26] C. Sternitzke and I. Bergmann, "Similarity measures for document mapping: A comparative study on the level of an individual scientist," *Scientometrics*, vol. 78, no. 1, pp. 113–130, Dec. 2009, doi: 10.1007/s11192-007-1961-z.

[27] U. Hany and L. Akter, "Wireless sensor network for information based domestic power management," in *2014 17th International Conference on Computer and Information Technology, ICCIT 2014*, Mar. 2003, pp. 180–184, doi: 10.1109/ICCITechn.2014.7073126.

[28] D. 2010/31/UE, "Directiva 2010/31/UE del Parlamento Europeo y del Consejo, d... - EUR-Lex." .

[29] V. C. Gungor, B. Lu, and G. P. Hancke, "Opportunities and challenges of wireless sensor networks in smart grid," *IEEE Trans. Ind. Electron.*, vol. 57, no. 10, pp. 3557–3564, Oct. 2010, doi: 10.1109/TIE.2009.2039455.

[30] G. P. J. Verbong, S. Beemsterboer, and F. Sengers, "Smart grids or smart users? Involving users in developing a low carbon electricity economy," *Energy Policy*, vol. 52, pp. 117–125, Jan. 2013, doi: 10.1016/j.enpol.2012.05.003.

[31] M. E. El-Hawary, "The smart grid - State-of-the-art and future trends," *Electr. Power Components Syst.*, vol. 42, no. 3–4, pp. 239–250, Mar. 2014, doi: 10.1080/15325008.2013.868558.

[32] M. A. Ortega-Vazquez, F. Bouffard, and V. Silva, "Electric vehicle aggregator/system operator coordination for charging scheduling and services procurement," *IEEE Trans. Power Syst.*, vol. 28, no. 2, pp. 1806–1815, May 2013, doi: 10.1109/TPWRS.2012.2221750.

[33] P. Siano and D. Sarno, "Assessing the benefits of residential demand response in a real time distribution energy market," *Appl. Energy*, vol. 161, pp. 533–551, Jan. 2016, doi: 10.1016/j.apenergy.2015.10.017.

View publication stats