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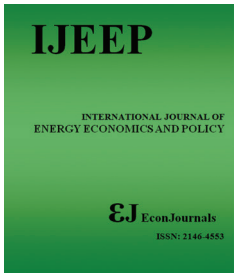

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Hybrid Energy to Drive Renewable Energy Diversity in Bibliometric Analysis

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ABSTRACT

Hybrid energy is a combination of two or more energy sources, some of which can be sourced from several renewable energies combined, or combined with fossil energy. Renewable energy diversity is implemented through the development of hybrid energy in order to obtain new energy sources that are more effective and efficient. Bibliometric analysis is directed to analyze topics that have novelty according to the time period of publication based on qualitative methods. Analysis of scientific literature sourced from scientific journals published in the last 10 years with the topic of hybrid energy. The results of study stated that several topics that had novelty were obtained to be used in the development of further knowledge and technology, especially in the development of hybrid energy including energy density, renewable energy system, supercapacitor, storage system, algorithm, electric vehicle, and energy system. The development of hybrid energy is very important to be followed up in order to get more comprehensive source of energy diversity and has full support for development of green technology that has relevance in sustainable development.

Keywords: Hybrid Energy, Renewable Energy, Green Technology, Knowledge Development, Bibliometric Analysis
JEL Classifications: K32, P48, Q42, Q49

1. INTRODUCTION

In the last 10 years, research related to the development of hybrid energy around the world has attracted a lot of attention for researchers in various fields of expertise including experts in the field of renewable energy. The development of hybrid energy continues to be carried out which produces various models, for example, various efforts are made to minimize electricity costs that must be incurred (Akorede et al., 2020), increasing the efficiency of operating system (Toopshekan et al., 2020), need for energy saving in manufacturing industry (Zheng et al., 2017), produce energy with uniform power generation (Jahangir et al., 2020). Research conducted related to the theme of hybrid energy investigates various efforts in developing renewable energy which is currently trend and becomes demand that must be grown because it is a priority requirement in the development of environmentally friendly technology and energy-saving technology. However, although research on hybrid energy has been studied by various aspects, the problem of need for hybrid energy development continues to be concern in various countries. Some of problems faced in effort to develop hybrid energy include finding the optimal power allocation from energy sources produced in hybrid energy (Liaquat et al., 2021), find an effective method to save energy optimally (Ye et al., 2020), efforts to increase the sensitivity and convergence of system (Mahmoudi et al., 2021). Efforts to find solutions to efficiently obtain hybrid energy have been carried out through various studies, including system optimization carried out with Homer software to increase the efficiency of charging stations, power systems and electricity (Ekren et al., 2021), smart hybrid energy system offers an alternative solution to reduce fuel

requirements and minimize logistics costs (Berardi et al., 2020), smart hybrid energy system to improve system performance to minimize operating costs and reduce emissions (Chamandoust et al., 2020).

However, the solutions that have been given from the development of various existing researches still tend to be partially applied, such as tests carried out in several countries such as China, Turkey, Iran. Pay close attention to various solutions that have been offered that have the uniqueness of each treatment in developing hybrid energy. However, in the context of developing knowledge relevant to hybrid energy, it is necessary to use new strategic approach. Uniquely, this new approach is applied to gain diversity of knowledge through the search for scientific articles to obtain new knowledge concepts that are important to be developed further. The relevance that can be followed up in this research is sought to strengthen the development of further research, especially on the concept of hybrid energy and generally for the development of renewable energy in Indonesia which is still not optimally implemented by stakeholders concerned.

The term hybrid energy is widely used in implementation research in supporting the acceleration of renewable energy development which is being promoted in various regions in the last 10 years. Therefore, an implementation study in strengthening hybrid energy research becomes an important thing to do immediately. The existence of hybrid energy is one step in creating a diversity of energy resources that can support the development of renewable energy with several advantages including being able to increase system efficiency, increase energy storage capabilities, and successfully reduce electricity costs. However, various technological innovations that have been carried out in creating hybrid energy more effectively and efficiently still need to be further improved in various sectors so that the resulting benefits can be fully felt by community to support the pattern of daily needs that utilize green technology. For this reason, knowledge development on the concept of hybrid energy applied aims to identify and disseminate various topics relevant to the concepts being tested that can be found in order to further support the development of research in various sectors. The use of meta-analytical models is possible in monitoring the scientific evolution of concept for hybrid energy in various scientific fields within a certain time span, which can shape research trends that can strengthen the current development of renewable energy. The scientific output produced is able to describe the latest developing issues so as to trigger the growth of new strategies that create sustainability in the development of renewable energy.

2. METHOD

Hybrid energy mapping is initial goal that this research wants to create as a step for the development of diversity in the evolution of knowledge that supports the development of renewable energy in various regions. The application of qualitative research is grown in the form of developing scientific literature sourced from scientific journals on the specificity of research topics on hybrid energy. Bibliometric analysis is a method for analyzing an evolutionarily large amount of scientific data that highlights topic in particular field (Donthu et al., 2021). Bibliometric is considered a set of tools used to analyze published knowledge mapping data including impact indicators, citation and co-citation analysis, and mapping (Danvila-del-Valle et al., 2019). The current growing research trend especially on the topic of hybrid energy needs to be carried out using scientific evolutionary monitoring. Monitoring and evaluation of development in various sectors of knowledge is developed through researched topics to obtain the latest issues that support development in renewable energy sector. Scientific journals as a source of knowledge that are studied in detail through the evolution of knowledge on the topic of hybrid energy are expected to have effective contribution to the development of green technology.

The visualization presented through the analysis of research data obtained from scientific journal searches is displayed in an attractive and elegant manner using VOSviewer. VOSviewer utilizes visual elements depicted through mapping techniques to assist in converting publication information in csv format so that new information is obtained (Abdullah et al., 2020). Scientific journals on the topic of hybrid energy that were systematically collected by researchers were conducted in August 2021 as primary data. The search for scientific journals takes place in 2011-2020 period or journal publications in the last 10 years. The search to find primary data is done by inputting keyword “hybrid energy” so that 4986 scientific journals are obtained. Furthermore, 5 time periods are made or the division of time clusters for journals published every 2 years is carried out to simplify and describe in detail issues that arise in each time cluster. Time clustering referred to journal publications is analyzed based on the findings obtained so that the pattern of progress in the evolution of knowledge can be known. Issues that arise based on the pattern of development on the evolution of knowledge with the topic of hybrid energy can be used as research novelties that can be explored to strengthen the development of latest knowledge and technology and support the continued development of renewable energy.

3. RESULTS AND DISCUSSION

The visualization is presented with detailed pattern in the form of network and its density is presented to explain the concept of hybrid energy. Hybrid energy is used as keyword in search application for scientific journals so that a number of data have been collected. The results of collection for scientific journals obtained 4986 manuscripts on the topic of hybrid energy. The range of publication times studied in scientific journals published in 2011-2020. Referring to the time span of scientific journals publication for the last 10 years, to facilitate the analysis, five clusters are presented that refer to publications per 2 years. A total of 357381 citations were detected during the time span of scientific journal publications. Furthermore, VOSviewer is used to present the results of database analysis from scientific journals that are collected in the form of network visualization and density.

The search process for scientific journals is divided into 5 time clusters that refer to the input of hybrid energy keywords. The division of clusters starts from Clusters I (2011-2012), II (2012-2014), III (2015-2016), IV (2017-2018), and V (2019-2020). In

Table 1, it can be seen that the number of citations and the number of cites per paper from Clusters I to V has decreased, and this decrease is in line with the length of publication time. However, the number of cites per year presented has increased, which means that many scientific articles published in the last year are mostly cited and utilized in the development of knowledge and research. The quality of scientific journal publications can be measured based on h-index, g-index, and hA-index values, where publication assessment refers to number of citations and number of publications produced. The size of the number of citations and number of publications obtained with the greater index value, better the assessment of scientific journal publication. Comparison of five clusters in scientific journal publications on the topic of hybrid energy can be used as guide for the growing use of scientific journals for the development of knowledge and technology so that positive trends can be created in this research.

Clustering of novelty on the topic of hybrid energy can help researchers and academics to direct issues to be published in scientific journals that are adapted to current needs (Table 2). New topics that can be developed in hybrid energy issues are presented in 3 time periods over a period of 6 years with seven main clusters as new topics that can be disclosed for further knowledge development. Several new topics that can be developed as part of novelty presented include battery energy storage, hybrid supercapacitor battery, binding energy, hybrid life cycle, and hybrid perovskite. This new topic can be an important study that allows experts to conduct research in the hope of producing novelties that can be utilized by all inhabitants of the earth.

The highest number of citations of 1205 was obtained by scientific journals published 6 years ago with average value per year of 200.83 (Table 3). This indicates that it is necessary to make scientific journals with high quality and have an element of novelty that can be maximally utilized by various interested parties. In addition, there is also a need for promotion system in scientific journal publications that are easily recognized by researchers and academics, including utilizing journal publishers that are well known and have reliable reputation in accordance with scientific topics. Novelty is important part in writing manuscripts that will be published in scientific journals, novelty in knowledge and technology according to scientific field being studied and in accordance with current needs is priority consideration for publication.

The ranking of top ten scientific journal publications on hybrid energy studies in 2011-2020 described based on several criteria shown in Table 4. Nine journals that ranked in top ten turned out to be from the same journal publisher, Elsevier. Although several journals have received rankings, number of citations obtained is still not large and still needs to be increased which is very likely to happen because it still takes longer time for publication to add significant number of citations. Promotion through various systems can be applied so that scientific journals can be known and used properly by various interested parties so that the impact on usefulness of scientific journals can be felt, and will indirectly increase the number of article citations and improve the reputation of journal concerned.

Table 1: Cluster hybrid energy

Publication year	2011-2012	2013-2014	2015-2016	2017-2018	2019-2020
Papers	1000	1000	998	998	990
Citations	108264	92085	75063	50728	31691
Cites/year	10826.40	11510.63	12510.50	12682.00	15845.50
Cites/paper	108.26	92.09	75.21	50.83	32.01
Authors/paper	3.53	3.6	3.81	3.99	4.19
h-index	157	141	132	107	74
g-index	275	246	206	146	101
hA-index	39	46	44	44	56

Table 2: Hybrid energy novelty clustering

Cluster	2019-2020	2017-2018	2015-2016
1	Battery energy storage, artificial neural network, diesel generator, energy management, hybrid renewable energy, hydrogen energy	Battery energy storage, energy management system, hybrid energy system, renewable energy system	Battery energy storage, hybrid renewable energy, renewable energy system, solar system, wind energy
2	Battery supercapacitor hybrid, electrochemical energy, hybrid capacitor, long cycle life	Asymmetric supercapacitor, energy storage application, hybrid supercapacitor, solid state supercapacitor	Energy conversion, energy dispersive spectroscopy, hybrid catalyst, hybrid material
3	Binding energy, asymmetric supercapacitor, higher energy density, hybrid structure, power density	Binding energy, Hybrid nanostructure, hydrogen evolution, photo catalyst	Asymmetric supercapacitor, energy storage device, hybrid nanostructure
4	Excellent performance, hybrid perovskite, wireless sensor network, sensor node	Hybrid life cycle assessment, greenhouse gas emission, hybrid perovskite	Hybrid energy, residual energy, wireless sensor network
5	Energy storage application, high energy efficiency, hybrid material	Energy absorption, hybrid structure, carbon nanotube	Hybrid perovskite, hybrid electrolyte, nanoparticle
6	Energy equation, hybrid nanofluid, solar energy system, heat transfer	Hybrid energy, wireless sensor network, solar panel	Hybrid energy storage, high power density, energy management strategy
7	Hybrid supercapacitor, high specific capacitance, excellent cycling stability	Hybrid energy storage, hybrid capacitor, energy storage devices	Hybrid supercapacitor, power density, long cycle life

Table 3: Citation count ranking 2011-2020

TC	APY	Title	Source Journal	Authors	Year
1205	200.83	Review and evaluation of hydrogen production methods for better sustainability	International journal of hydrogen energy	I Dincer, C Acar	2015
1161	145.13	Navigating paradox as a mechanism of change and innovation in hybrid organizations	Academy of management journal	J Jay	2013
792	99.00	Strongly coupled inorganic/nanocarbon hybrid materials for advanced electro catalysis	Journal of the american chemical society	Y Liang, Y Li, H Wang, H Dai	2013
691	115.17	Highly Active and Stable Hybrid Catalyst of Cobalt-Doped FeS2 Nano sheets–Carbon Nanotubes for Hydrogen Evolution Reaction	Journal of the american chemical society	DY Wang, M Gong, HL Chou, CJ Pan	2015
686	137.20	Energy-efficient hybrid analog and digital precoding for mm Wave MIMO systems with large antenna arrays	IEEE Journal on Selected Areas in Communications	X Gao, L Dai, S Han, I Chih-Lin	2016
592	74.00	Advances and trends of energy storage technology in micro grid	International Journal of Electrical Power & Energy	X Tan, Q Li, H Wang	2013
567	70.88	Synthesis of a novel and stable g C 3 N 4–Ag 3 PO 4 hybrid nanocomposite photo catalyst and study of the photocatalytic activity under visible light irradiation	Journal of Materials Chemitry A	S Kumar, T Surendar, A Baruah	2013
508	84.67	Hybrid germanium iodide perovskite semiconductors: active lone pairs, structural distortions, direct and indirect energy gaps, and strong nonlinear optical properties	Journal of the american chemical society	CC Stoumpos, L Frazer, DJ Clark, YS Kim	2015
465	46.50	A survey on clustering algorithms for wireless sensor networks	Computer communications	O Boyinbode, H Le, M Takizawa	2011
460	65.71	EBK-means: A clustering technique based on elbow method and k-means in WSN	International Journal of Computer Applications	P Bholowalia, A Kumar	2014

Table 4: Ranked in the top ten journals 2011-2020

Rank	Authors	Title	Source Journal	Publisher	Year	TC	APY
1	C Pornet, C Gologan, PC Vratny, A Seitz, O Schmitz	Methodology for sizing and performance assessment of hybrid energy aircraft	Journal of Aircraft	Aerospace Research Central	2015	121	20.17
2	H Hosseini, S Shahrokhian	Self-supported nanoporous Zn–Ni–Co/Cu selenides microball arrays for hybrid energy storage and electrocatalytic water/urea splitting	Chemical Engineering Journal	Elsevier	2019	51	25.50
3	S Hajiaghasi, A Salemnia, M Hamzeh	Hybrid energy storage system for microgrids applications: A review	Journal of Energy Storage	Elsevier	2019	160	80.00
4	S Sun, Z Xie, Y Yan, S Wu	Hybrid energy storage mechanisms for sulfur-decorated Ti3C2 MXene anode material for high-rate and long-life sodium-ion batteries	Chemical Engineering Journal	Elsevier	2019	58	29.00
5	S Mandal, BK Das, N Hoque	Optimum sizing of a stand-alone hybrid energy system for rural electrification in Bangladesh	Journal of Cleaner Production	Elsevier	2018	153	51.00
6	M Masih-Tehrani, MR Ha'iri-Yazdi, V Esfahanian	Optimum sizing and optimum energy management of a hybrid energy storage system for lithium battery life improvement	Journal of Power Sources	Elsevier	2013	180	22.50
7	SKA Shezan, S Julai, MA Kibria, KR Ullah	Performance analysis of an off-grid wind-PV (photovoltaic)-diesel-battery hybrid energy system feasible for remote areas	Journal of Cleaner Production	Elsevier	2016	167	33.40
8	A Santucci, A Sorniotti, C Lekakou	Power split strategies for hybrid energy storage systems for vehicular applications	Journal of Power Sources	Elsevier	2014	155	22.14
9	R Xiong, H Chen, C Wang, F Sun	Towards a smarter hybrid energy storage system based on battery and ultracapacitor-A critical review on topology and energy management	Journal of Cleaner Production	Elsevier	2018	74	24.67
10	MA Baseer, A Alqahtani, S Rehman	Techno-economic design and evaluation of hybrid energy systems for residential communities: Case study of Jubail industrial city	Journal of Cleaner Production	Elsevier	2019	43	21.50

Network and density visualization displayed in scientific journal publications 2019-2020 on the topic of hybrid energy as part of an analytical study in research. The visualization presented shows the relationship between the studied themes that are interrelated with each other which are connected between nodes with a line that has a certain color. A line with a certain color connects two nodes which indicate the existence of a relationship and the existence of a connection between the topics studied. The research topic is marked with a round node with a color type and has certain dimensions that differ from one another depending on the cluster that the group belongs to. The size of the node indicates the number of research topics studied, the more research topics are studied so that the size of the resulting node is also greater. The same color is shown in each node cluster which indicates the grouping of a research topic. Density visualization is determined based on the brightness level of the color from blue to green to yellow. The

more yellow it shows or has a clearer brightness level, the topic under study becomes a favorite and is considered to have a high trend for further research. Figure 1 shows that the renewable energy system and energy density have the largest node size and have a yellow color with the highest brightness level compared to the others. This shows that the two topics studied are the most widely discussed and researched, so it is important to follow up to get new research results that can be useful for the development of renewable energy that is currently being promoted.

The network and density visualization shown in Figure 2 can be seen that supercapacitors and renewable energy systems are the two topics that are the main focus of research in 2017-2018. The level of brightness of color and the size of the node which is the largest compared to other topics studied are the determinants of the two topics being the focus of research. Although there are still several other topics that also make important contributions, including hybrid nanofluid, energy generation, solar panels, and high specific energy.

Storage systems, supercapacitors, and algorithms are main focus of research on the topic of hybrid energy which refers to network and density visualization which can be seen in Figure 3. In addition to three topics that became focus of research in 2015-2016, there are also several other topics that have contributed important research in this time span include asymmetric supercapacitor, wireless sensor network, synthesis, and high energy density.

Figure 4 shows network and density visualization in research on the topic of hybrid energy with two dominant focuses including electric vehicles and energy systems. These two main topics have dominance in terms of color brightness and node dimensions with certain color clusters so that they become priority topics studied in 2013-2014. Many other topics also have major contributions but have no dominant influence, including algorithms, wireless sensor networks, storage, nanocrystals, energy density, and hybrid solar cells.

4. CONCLUSION

The expansion of renewable energy is carried out through the development of hybrid energy diversity into environmentally friendly energy needs which are the demands of today's needs. The development of topics relevant to hybrid energy needs to be strengthened as an effort to improve the development of knowledge and technology for the world's energy needs. The results revealed in this research state that the use of hybrid energy themes published in various scientific journals 2011-2020 produces topics that have novelty and very important for further

Figure 1: Network and density visualization 2019-2020

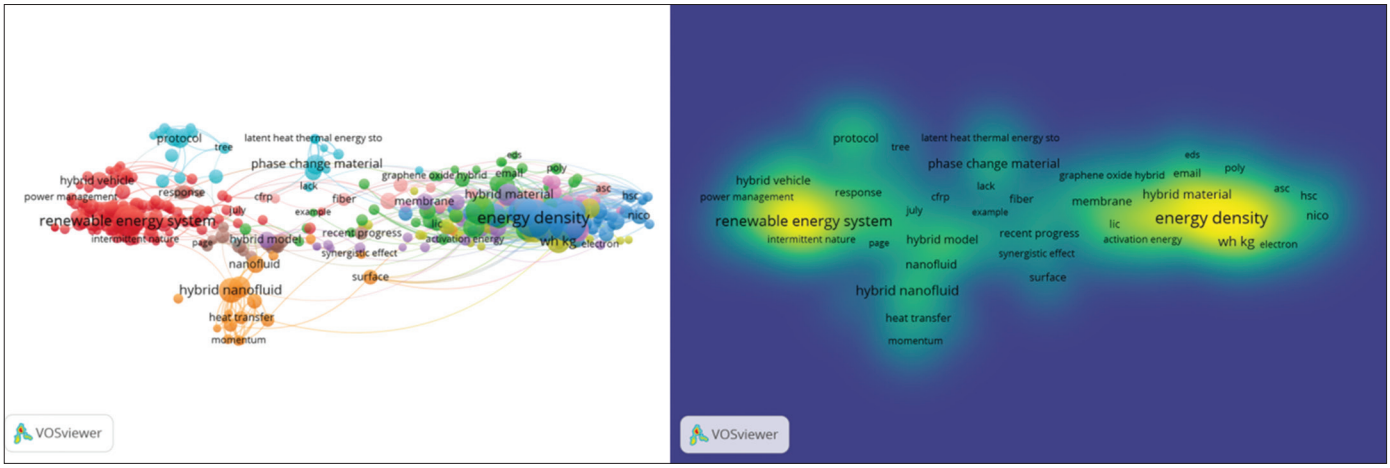


Figure 2: Network and density visualization 2017-2018

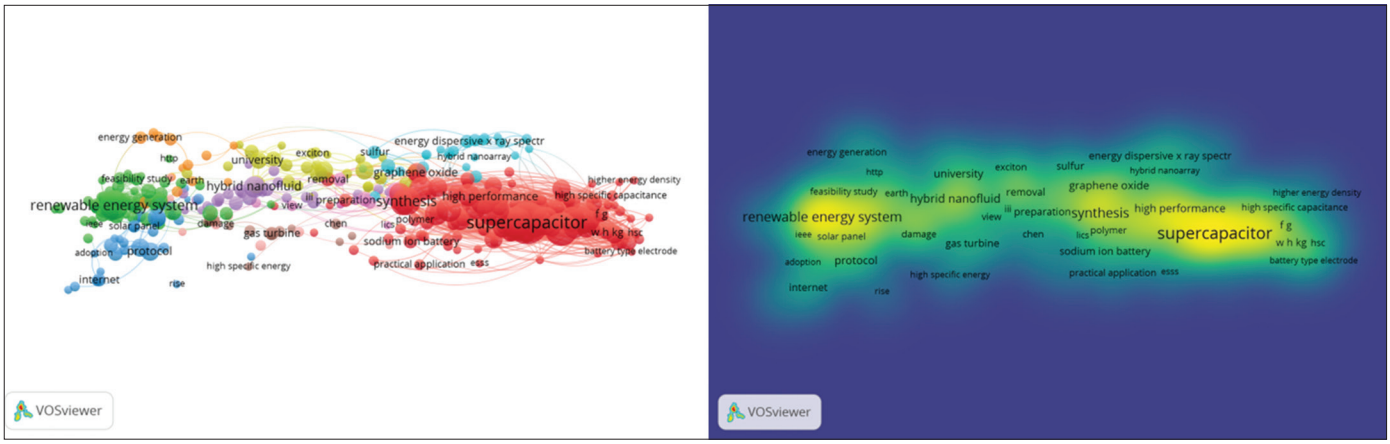


Figure 3: Network and density visualization 2015-2016

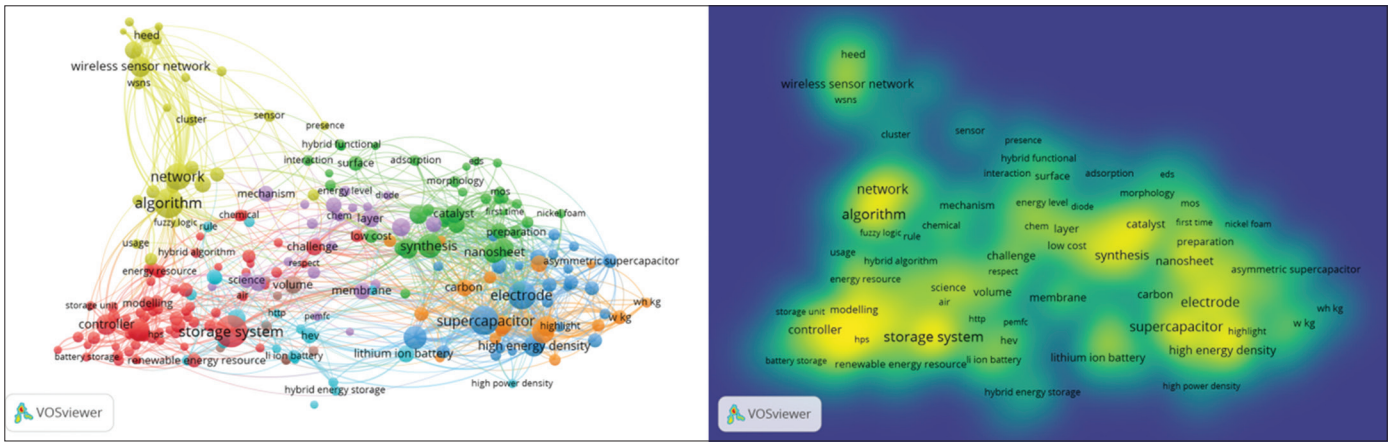
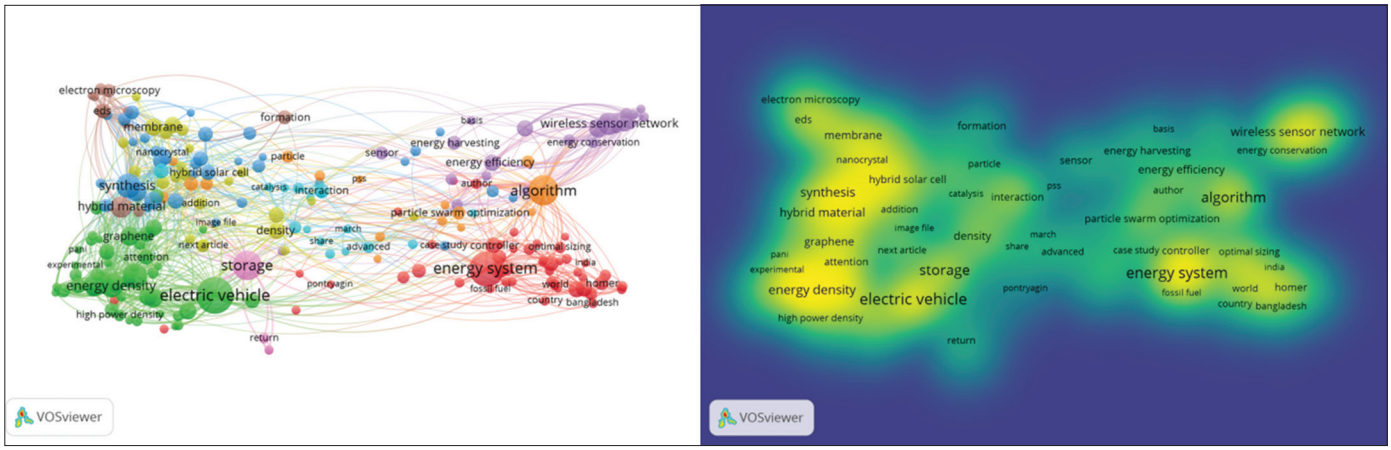


Figure 4: Network and density visualization 2013-2014



development including energy density, renewable energy system, supercapacitor, storage system, algorithm, electric vehicle, and energy system. In addition, there has been an increase in the number of cites per year in the last 10 years in disclosure of hybrid energy. The positive trend in citing hybrid energy occurs along with the importance of this theme to be developed further in order to strengthen the development of knowledge and technology that has potential to have novelty and innovation. Relationships between topics that can be displayed attractively through network visualization and density visualization make it easier to understand in determining the novelty of topic. The visualization shown is able to distinguish the dominant research topics and those that are rarely studied. Promotion of the publication of scientific journals with topics that have novelty needs to be done through publishers who have good reputation so that it is easier to be known and disseminated more quickly to public.

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