Generation Expansion Planning: A Bibliometric Review

W Sunanda[1,*]

[1]*Department of Electrical Engineering, Universitas Bangka Belitung, Bangka, Indonesia*

[*]*Email: wahrisunanda@ubb.ac.id*

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Abstract

Generation expansion planning is a prominent topic of energy-related scientific discourse. Due to operational constraints, the penetration of renewable energy sources, and uncertainty, there have been numerous changes in the planning of generation expansion. This article provides a bibliometric analysis of recent research on generational expansion planning. Relevant authors, sources, terms, disciplines, and conceptual analysis are used for bibliometric analysis. This bibliometric is based on a Scopus database data set for the years 2013 to 2023.

Keywords: *generation expansion planning, energy, renewable energy, bibliometric analysis*

I. INTRODUCTION

The initial objective of generation expansion planning is to obtain a cost-effective plan for meeting electrical energy demand[1] Along with the rise in population and economic activity, the demand for electrical energy increases, necessitating electrical energy with high levels of dependability and low prices[2]. To accommodate anticipated load growth, planned generation expansion must consider a number of factors, including (1) the type of technology in the generator, (2) the capacity of the generator, (3) the location of the generator, and (4) the time at which the generator will be constructed[3]. It is possible to plan for short-term generation expansion but not for medium- or long-term expansion[4]. The planning of generation expansion involves numerous factors, including techno-economic, financial, policy, spatial, and environmental factors. Diverse planning models for generation expansion have been developed in order to obtain results, conclusions, and policy recommendations[5] in order to assure energy sustainability[6].

In addition to minimizing costs, the planning of power plant development also focuses on climate change mitigation and the incorporation of renewable energy sources[7]. In addition to the power plant technology employed, generation expansion planning considers capacity data, techno-economic parameters, scenario settings, time frames, and planning and operating constraints[8]. As the supply of fossil fuels declines, planning for generation expansion by integrating new and renewable energy into the existing power system is a crucial step for mitigating climate change and increasing the use of new renewable energy technologies[9]. Nonetheless, it is crucial to consider the severe impact of uncertainty from new renewable energy sources, as it will compromise the dependability of planning[10].

In addition to developments, generation expansion planning takes into account the electricity market and competition[11] the global environment[12] demand-side management, energy supply security, distributed generation, generator maintenance scheduling, smart grid, transmission development planning[13], fuel supply costs, clean coal technology, CO_2 capture storage[14], uncertainty and dependability, operational constraints[15], and policies pertaining to new and renewable energy[16]**.** In addition to evaluating the hydropower potential[6][17] and integrating new renewable energy and optimal unit commitment[18],

generation expansion planning in the electricity system is also conducted using LOLE criteria[19].

On the basis of their time horizon (static or dynamic), uncertainty management (deterministic or stochastic), market structure (regulated or deregulated), and network topology (single node or network), models for generation expansion planning can be categorized[20]. Generation expansion planning was initially used to determine the type, capacity, location, and lifespan of the generator required to satisfy the increased demand for electrical energy. However, the environment, energy security, and policy objectives are currently considered in generation expansion planning[21].

A comprehensive literature review on generation expansion planning is conducted in order to identify emerging trends and opportunities[5][19][22]. Among the evaluations conducted[23] was bibliometric evaluation. The R-package is used in generation expansion planning for bibliometric analysis that includes authors, reference sources, word, field, thematic, and conceptual analysis[24]. In comparison to narrative review techniques and meta-analyses[25], bibliometrics facilitate the construction of an exhaustive database[26]. In numerous disciplines[27], bibliographic techniques have been implemented[28]. This article will describe the bibliometric methodology in section 2, the results of the bibliometric analysis in section 3, and potential research topics of generation expansion planning in section 4.

II. MATERIALS AND METHODS

Methods Bibliometrix is a one-of-a-kind application created in the statistical computation and graphical R programming languages, with a logical bibliometric methodology[29]. Bibliometrix includes routines for importing bibliographic data from SCOPUS[30], Web of Science by Clarivate Analytics[31], PubMed, Digital Science Dimensions, and Cochrane databases, as well as bibliometric tools for examining scientific collaboration, co-word analysis, and co-citations[32]. The collected data set will be subjected to five analysis; author, source, word, field and thematic, as shown in Fig. 1.

III. RESULTS AND DISCUSSIONS

This section will explain author analysis, including the production of leading authors and the annual scientific output, as well as source analysis, including relevant sources, Bradford's laws, and source development.

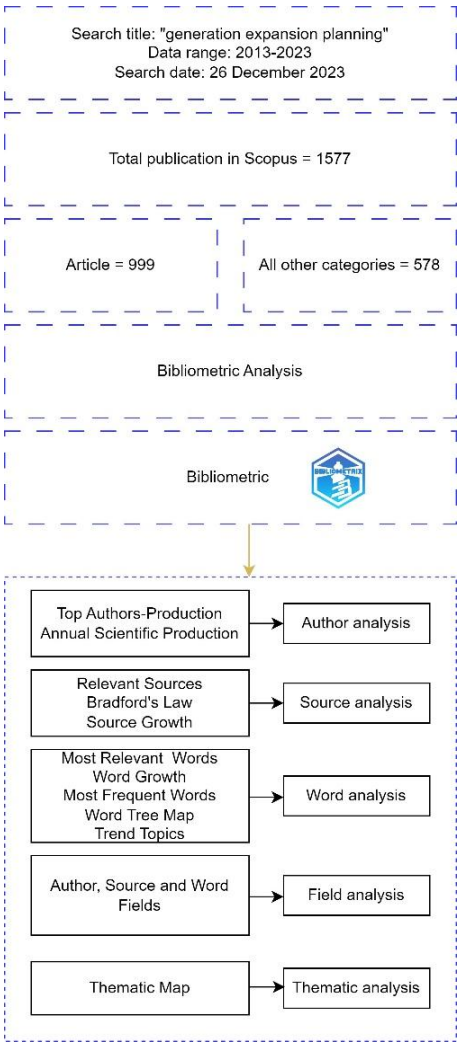

Figure 1. Methods of bibliometric review

The author, source, and word field analyses follow the word analysis, which consists of the most pertinent words, word growth, the most prevalent words, word tree maps, and trend topics. Thematic analysis will ultimately elucidate the development of themes and thematic maps.

The data in Table 1 pertains to the sources utilized for the 2013–2023 bibliometric study. As data sets, 1577 journal articles, conference proceedings, books, and book chapters with a total of 3876 authors are utilized.

A. Analysis of author

Fig depicts the leading 10 authors with the most publications out of 3876 authors during the period 2013–2023. Fig depicts the number of articles published from 2013 to 2023. The number of research articles on generation expansion planning will increase from 112 in 2013 to 203 in 2020. 75 articles on generation expansion planning have been published through the middle of 2023.

Table 1 A Brief Description of the Dataset

	Description	Results
Main Information	Timespan	2013-2023
	Documents	1577
	Average citations per documents	16.98
Document Types	Articles	1003
	Article; Book chapter	64
	Article; Proceedings paper	444
	Keywords Plus	7065
Authors	Author's Keywords	3847
	Authors	3876
	Documents per author	0.41
	Authors per document	2.46
	Co-Authors per documents	3.62

B. Analysis of source

From 2013 to 2023, Fig depicts the top ten influential sources for generation expansion planning. Applied Energy and IEEE Transactions on Power Systems are ranked first with 81 articles each. The law of Bradford outlines the distribution of citations in a particular research field. It can identify the sources and journals that are most frequently cited.. As depicted in Fig, the quantity of articles has been classified into eleven primary sources. Source occurrence accumulation is controlled by the pertinent source growth. The number of Applied Energy journal articles increased substantially between 2013 and 2023.

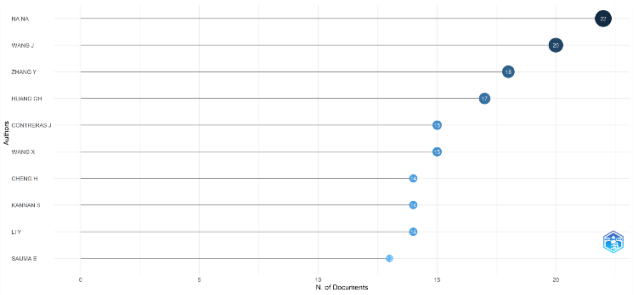

Figure 2. The leading 10 authors in the generation expansion planning research. Analysis of 2013–2023 data with the Biblioshiny R package and the Scopus database

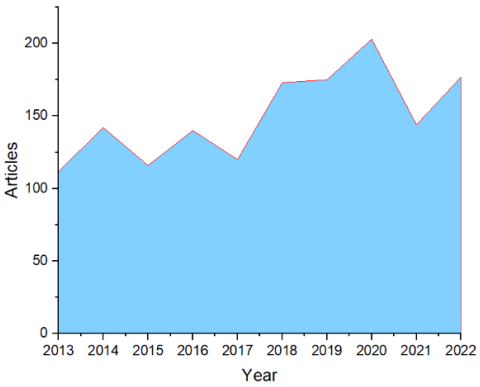

Figure 3. The annual scientific publication activities in the generation expansion planning research. Analysis of 2013–2023 data with the Biblioshiny R package and the Scopus database

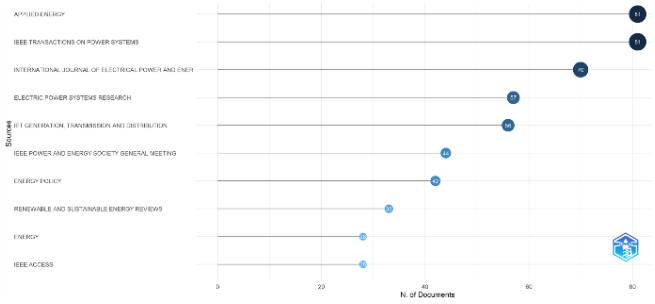

Figure 4. The most authoritative sources in the generation expansion planning research. Analysis of 2013–2023 data with the Biblioshiny R package and the Scopus database

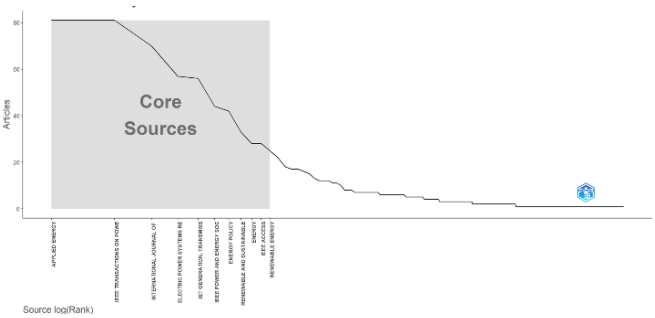

Figure 5. The law of Bradford in the generation expansion planning research. Analysis of 2013–2023 data with the Biblioshiny R package and the Scopus database

C. Analysis of word

After researching the appropriate author and sources, the word analysis includes the generation growth planning-related title, key word, and abstract. Publication keywords may be useful indicators of research interests in the planning of generation expansion, displaying the most explored themes. As specified in the author's key terms, Fig depicts the ten most frequently occurring words. The most prominent terms are "generation expansion planning", "transmission expansion planning", and "renewable energy".

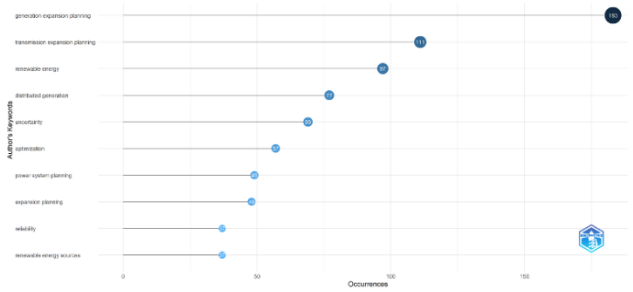

Figure 6. The most pertinent term in the generation expansion planning research. Analysis of 2013–2023 data with the Biblioshiny R package and the Scopus database

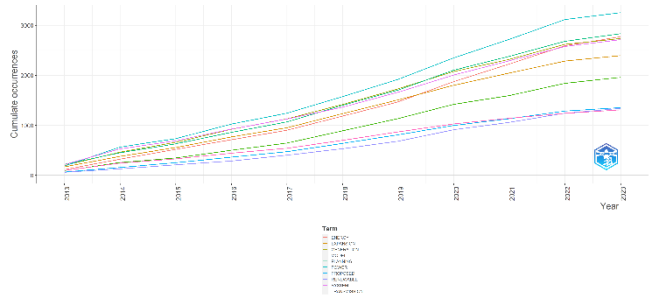

Figure 7. The word growth in the generation expansion planning research. Analysis of 2013–2023 data with the Biblioshiny R package and the Scopus database

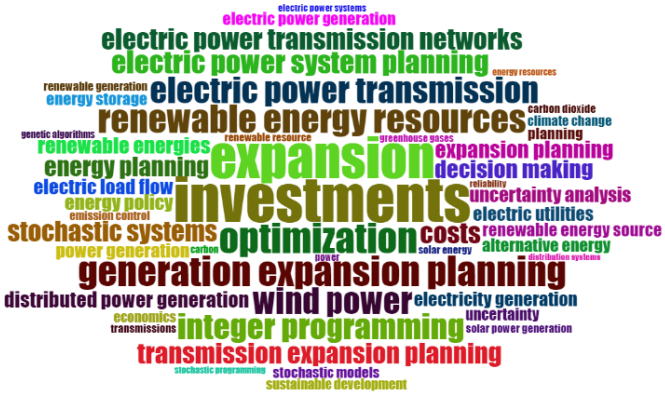

Figure 8. The most thypical phrases in the generation expansion planning research. Analysis of 2013–2023 data with the Biblioshiny R package and the Scopus database

Moreover, as shown in Fig, the annual growth rate of the terms "energy", "expansion", "generation", "transmission", "planning", "power," and "renewable" indicates that their use is increasing. Word clouds (also known as most frequent words) are graphical representations of words that highlight more often occurring terms. This graphic can help academics quickly collect data from articles and plot generational expansion. Fig illustrates the most frequently used word in connection with the event.

D. Analysis of field

Fig depicts the Sankey Diagram in three dimensions, illustrating the relationships between keywords (on the left), authors (in the middle), and journals (on the right). The graph depicts the authors' journal contributions and their preferred keywords. The density of the connection lines increases as the number of relationships between variables increases, according to the Sankey Diagram. G.H. Huang has written articles on "uncertainty" and "stochastic programming" in the journals Applied Energy, International Journal of Electrical Power, Energy, Renewable and Sustainable Energy Review, Journal of Cleaner Production, and Renewable Energy.

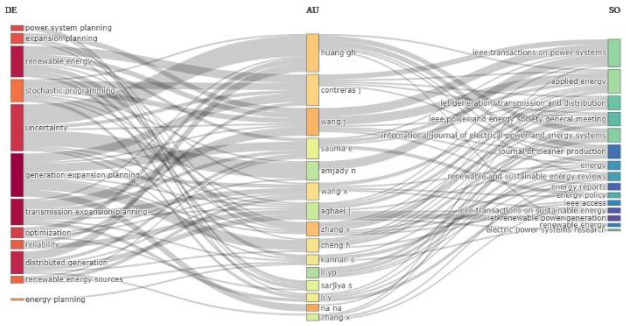

Figure 9. The Sankey Diagram analysis in the generation expansion planning research. Analysis of 2013–2023 data with the Biblioshiny R package and the Scopus database

E. Analysis of thematic

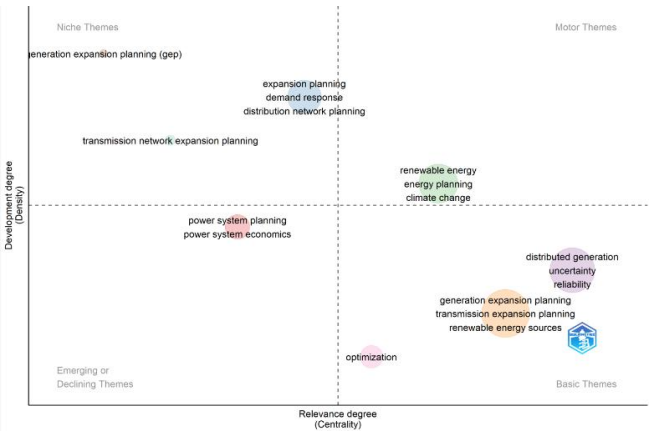

Figure 10. The thematic analysis in the generation expansion planning research. Analysis of 2013–2023 data with the Biblioshiny R package and the Scopus database

Thematic maps, which illustrate the conceptual framework of a certain research issue (Fig), are one type of scientific mapping technique. The majority of scholarly works and citations on "generation expansion planning" use motor theme phrases. Despite the fact that expansion planning, demand response, and

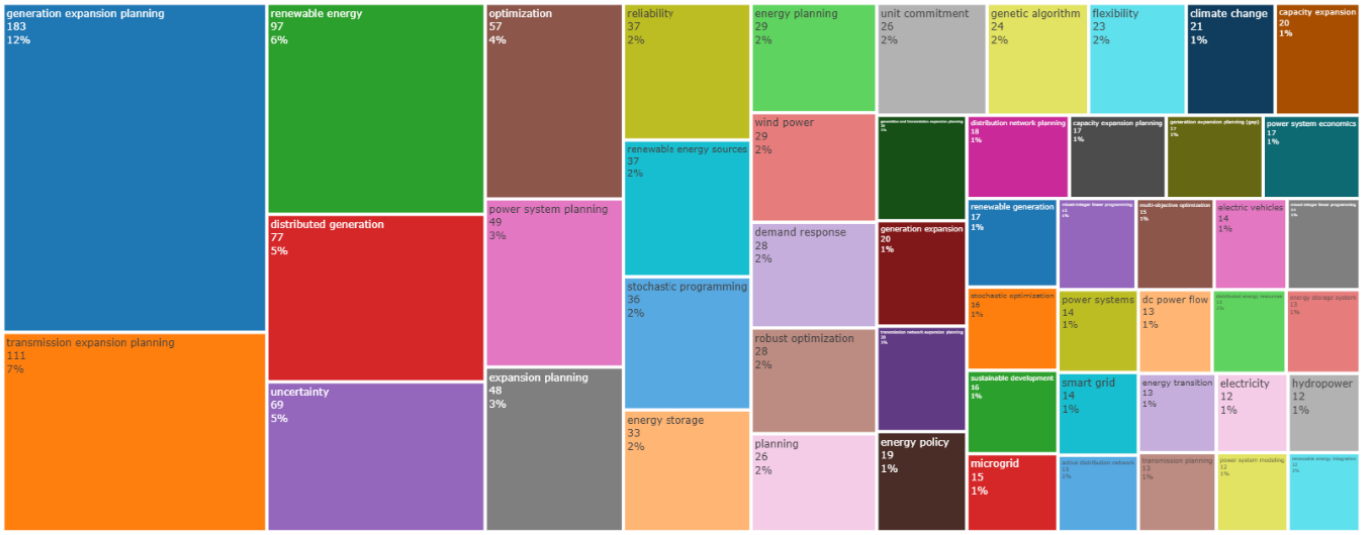

Figure 2. The term tree map used in the research on generational expansion planning. Analysis of 2013–2023 data with the Biblioshiny R package and the Scopus database

distribution network planning are regarded highly sophisticated yet isolated (niche) difficulties, they have high centrality and low density. Although this keyword collection was more efficient in past years, its relevance to the topic has dwindled over time. The terms power system planning and power system economics, on the other hand, relate to a subset of new issues with low intensity and centrality. This keyword's relationship to other words, as well as its relevance for other terms, is quite poor.

A high-density, decentralized system's foundational themes are distributed generation, unpredictability, dependability, and optimization. This keyword group has a limited internal relationship. Depicts the results of a R biblioshiny analysis of frequently occurring keywords in the abstracts of generation expansion planning research publications. Keyword occurrence is depicted as a keyword tree map. According to the keyword tree map, generation expansion planning appears the most often with 183 keywords (12%), followed by transmission expansion planning with 111 keywords (7%), renewable energy with 97 keywords (6%), distributed generation with 77 keywords (5%), and uncertainty with 69 keywords (5%). The frequency and distribution of frequently occurring keywords are illustrated in displays the trending issues based on generation growth planning from 2013 to 2023. The line indicates the author's publication history; dimension of bubble denotes the number of documents; and the intensity of the color represents the total number of citations each year. In the early years, "generation planning" and "investment cost" were hot concerns. Recent terminology linked with capacity expansion planning includes "energy transition", "renewable energy", "capacity expansion planning", "machine learning", and "uncertainty".

IV. CONCLUSIONS

This bibliometric study used author analysis, source analysis, word analysis, field analysis, and thematic analysis to investigate generational growth planning from 2013 to 2023. According to the authors' analysis, 10 authors are extremely prolific in generation expansion planning. Bradford's law states that the eleven most relevant sources are the primary sources from the standpoint of the source. The word analysis identifies the most essential themes by identifying the most relevant and frequent words in the study's title, abstract, and keyword. Recent generation expansion planning research has concentrated on the following trend topics: energy transition, renewable energy, capacity expansion planning, machine learning, and uncertainty. Three field investigations uncovered author contributions in a variety of subject-matter journals. On the thematic map, the field of generation expansion planning is divided into four quadrants: fundamental, motor, emergent, and niche themes.

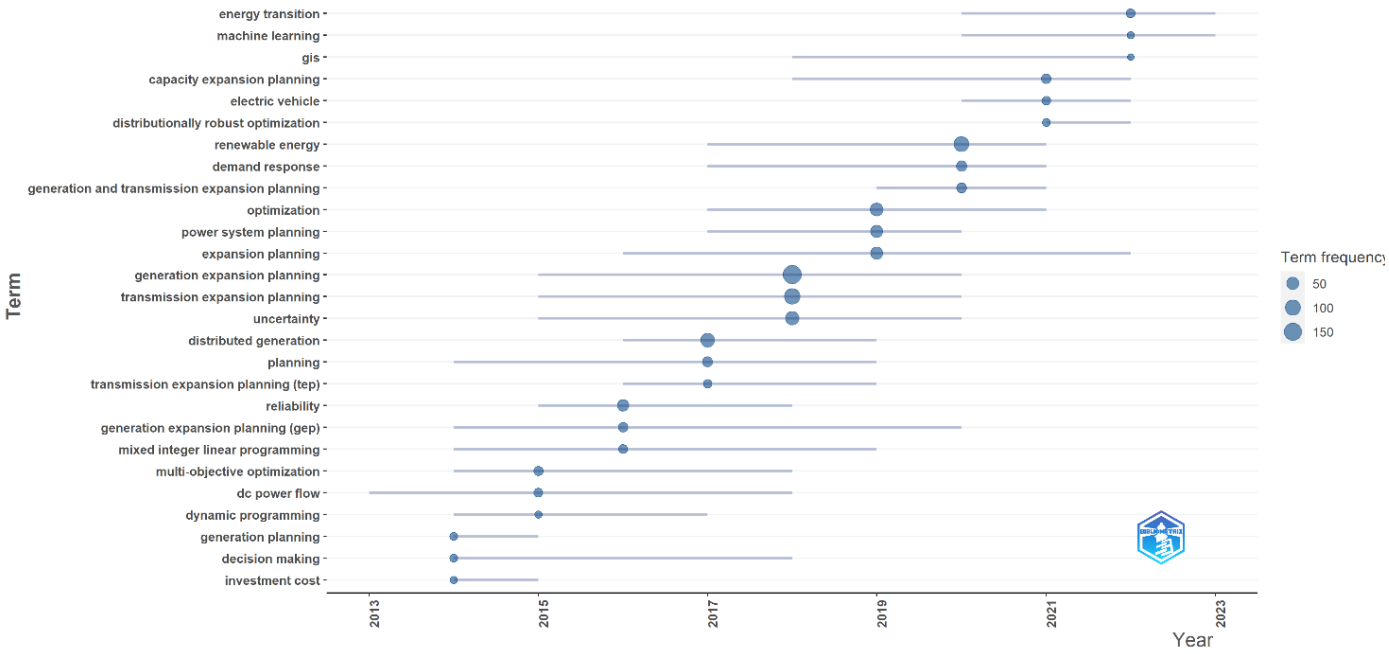

Figure 3. The trend topics in the generation expansion planning research. Analysis of 2013–2023 data with the Biblioshiny R package and the Scopus database

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