



Key Issues in The Management of Ultra High Voltage Engineering from The Perspective of Bibliometrics

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Abstract. Ultra high voltage engineering is an important carrier of the new energy supply system. By analyzing the published literature on ultra high voltage engineering management, it is possible to clarify the key issues that need to be addressed in each period and serve the construction of ultra high voltage engineering in the unconventional stage. This article uses CiteSpace software to analyze literature on the topics of "ultra high voltage" and "management" published in CNKI from 2014 to 2024, and constructs a knowledge graph of ultra high voltage engineering management research. Research has found that the main research institution for ultra high voltage engineering management is the power grid company, and the most frequently mentioned keywords include converter stations, transmission lines, construction management, engineering construction, quality control, safety management, substations, etc. It is recommended to strengthen quality control throughout the entire process, reduce safety risks from the source, and optimize the management mode of ultra high voltage construction.

Keywords: ultra high voltage engineering, bibliometrics, project management, key issues

1 Introduction

The construction of ultra high voltage engineering plays an important role in the historical process of the power industry, and has become the "main artery" of energy transportation in China's "West East Power Transmission, North South Power Supply, Water Fire Mutual Assistance, and Wind Solar Complementary". Compared to conventional power grid construction projects, ultra high voltage projects have special characteristics in terms of technology, region, and construction, requiring higher-level demonstration and innovation in technology, equipment, personnel management, and other aspects. With the passage of time, the focus of ultra high voltage engineering management continues to change. By analyzing published literature on the topic and exploring the changing trends of research topics, it is possible to identify key issues that need to be addressed in each period and propose targeted solutions. In the new stage of ultra high voltage engineering construction, it is of great practical significance to explore the key issues and evolutionary trends of academic research on ultra high voltage engineering management, and propose improvement measures for engineering management.

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Ye et al. (2024) conducted a bibliometric analysis of research hotspots and trends in risk management of foundation pit engineering, using 1367 articles from the CNKI and WOS core databases as research objects [1]. Qu et al. (2024) conducted a visual analysis of 4765 articles on the theme of "construction engineering+safety management" included in China National Knowledge Infrastructure [2]. Jia et al. (2024) organized 1544 literature on safety management in domestic subway construction, and conducted visual analysis from four aspects: publication volume characteristics, author collaboration relationships, literature attributes, and clustering relationships [3]. Dan et al. (2024) selected literature in the field of smart construction sites in China over the past 10 years, analyzed the overall overview, number of publications, and journals of research results in this field, and drew keyword co-occurrence network graphs, clustering graphs, timeline graphs, and mutation word graphs [4]. Yuan (2024) conducted a bibliometric study on the direction of engineering management, and preliminarily analyzed the hotspots and trends in the field of engineering management research [5]. Liu et al. (2023) used literature statistical analysis, literature content analysis, and other research methods to summarize academic research papers on digital twin technology in the field of construction engineering at home and abroad [6]. Feng et al. (2023) selected important international journals in the field of engineering and project management to conduct a systematic review and bibliometric analysis of innovative research in construction engineering from an international perspective [7]. Ai et al. (2023) selected 1014 literature on green building construction management as a sample, analyzed the distribution of literature, core authors, research institutions, and high-frequency keywords, and drew a knowledge graph [8]. Wang et al. (2022) applied quantitative bibliometric method and qualitative technical paradigm theory analysis method to explore the emergence, types, development, transformation, and decline of different engineering innovation technologies [9]. Wang et al. (2021) analyzed the research trend in the field of engineering project risk management from the perspectives of publication quantity and development trends, author groups and publishing institutions, classic journals and important literature [10].

In the unconventional development stage of ultra high voltage engineering, this paper summarizes academic research papers in the field of ultra high voltage engineering management in China through methods such as literature statistical analysis and literature content analysis. Explore the key issues and evolving trends in academic research on ultra high voltage engineering management, and propose targeted improvement measures.

2 Research methods and data sources

Using the theoretical and technical support of bibliometrics, CiteSpace is employed as the research tool. Bibliometric analysis is a quantitative research method that uses mathematical statistics and other methods to explore the publication patterns of research papers, objectively describe, predict, and evaluate different countries, regions, research institutions, or researchers to reveal the research status and development trends in a certain field. It has the advantages of objectivity, quantification, and modeling.

CiteSpace is a visualization software developed based on programming languages for scientific literature analysis. It can transform a large amount of complex literature data into a visual graph with multiple, temporal, and dynamic characteristics, which can intuitively understand the research progress and cutting-edge trends in a certain field. In CiteSpace software, a knowledge graph for ultra high voltage engineering management research is constructed using an embedded analysis and computation model.

This article selects data from China National Knowledge Infrastructure and sets the search topics as "ultra high voltage" and "management". In 2014, the National Energy Administration issued a notice on accelerating the construction of 12 key transmission channels in the Action Plan for Air Pollution Prevention and Control, marking the first wave of construction for ultra high voltage projects. Therefore, Time Slicing is set from 2014 to 2024. To prevent bias in analysis results caused by different recording methods, conference papers, newspapers, and some policy literature are excluded. To simplify the network branches, set the Year Per Slice to 1, set the node filtering method g-index to "k=20", and check options such as "Path Finder, various time periods, and overall network". By using "Keywords" in CiteSpace to construct a keyword knowledge graph and clustering graph, high-frequency keywords can be analyzed to reveal the research hotspots and development trends of ultra high voltage engineering management to the greatest extent possible.

3 The current status of management research on ultra high voltage engineering in China

3.1 Number of publications

Figure 1 shows the annual trend of literature publication in the field of ultra high voltage engineering management from 2014 to 2024. With the first wave of construction of ultra high voltage projects, the management of ultra high voltage projects is facing many practical problems. From 2014 to 2019, the construction of ultra high voltage has entered a phase of acceleration, and the number of literature on related theories and methods has continued to increase. The research focuses on the practical application of management theory and technology in ultra high voltage engineering. Since 2020, the construction of ultra high voltage has entered a stage of high-quality development, with a significant accumulation of relevant theoretical and methodological research and a decrease in the number of literature. The research focuses on the lean and digital aspects of ultra high voltage engineering management.

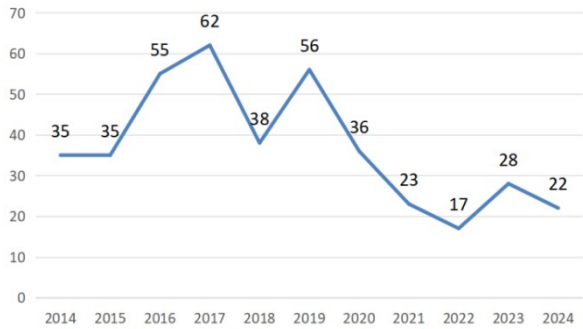


Fig. 1. Publication volume of literature in the field of ultra high voltage engineering management.

3.2 Main publishing institutions

Table 1 shows the publication volume of various institutions in the field of ultra high voltage engineering management from 2014 to 2024. Among them, State Grid Communication Construction Company, State Grid Corporation of China, and State Grid DC Corporation ranked among the top three in terms of the number of publications, significantly higher than other institutions. Except for Beijing Luosida Technology Development Company, North China Electric Power University, and Shandong Chengxin Engineering Construction Supervision Company, the institutions with a large number of publications all come from two enterprises, State Grid and Southern Power Grid. From the distribution of major publishing institutions, it can be seen that research on ultra high voltage engineering management needs to be based on engineering construction practice, relying on joint research by power grid enterprises, construction units, universities and other institutions.

Table 1. Main publishing institutions in the field of ultra high voltage engineering management.

Institution	quantity
State Grid Communication Company	29
State Grid Corporation of China	27
State Grid DC Corporation	20
Shandong Electric Power	14
Mong Dong Power Company	13
State Grid Material Company	12
Jiangsu Electric Power Company	12
Zhejiang Electric Power Company	12
Beijing Luosida Technology Development Co., Ltd	20
North China Electric Power University	9

Jibei Electric Power Company	9
Shandong Chengxin Engineering Construction Supervision Company	8
China Electric Power Research Institute	8
Anhui Electric Power Company	8
Hubei Electric Power Company	8
China Southern Power Grid Ultra High Voltage Transmission Company	8
Henan Electric Power Company	8
Gansu Electric Power Company	7

3.3 Keyword co-occurrence analysis

The frequency of keyword occurrence reflects the research popularity of the keyword in the research field. Import 407 sample data into CiteSpace software and select the "keywords" option to run, generating a co-occurrence knowledge graph of ultra high voltage engineering management keywords, as shown in Figure 2. Through software analysis, besides "ultra high voltage", the most frequently occurring keywords are converter stations, transmission lines, construction management, engineering construction, quality control, safety management, substations, Internet of Things, influencing factors, operation and maintenance management, management mode, and response measures. It can be seen that converter stations, transmission lines, and substations are the physical objects of ultra high voltage engineering management. Construction management and operation and maintenance management are the two main lines of ultra high voltage engineering management. Quality control and safety management are the key directions of ultra high voltage engineering management. Analysis of influencing factors, optimization of management models, and implementation of response measures are the main research contents of ultra high voltage engineering management.



Fig. 2. Knowledge graph of co-occurring keywords in literature.

3.4 Keyword clustering analysis

Cluster analysis can reflect the thematic categories of a research field. The smaller the cluster number, the more keywords it contains, and this research has received more attention. Use Citespace software for analysis, set the node type to keywords, and select LLR algorithm. After conducting systematic operations on keyword clustering in the research of ultra high voltage engineering management, weak related keywords were removed, resulting in 9 main clusters including transmission lines (#1), converter stations (#2), substations (#3), and construction (#4), as shown in Figure 3. It can be seen that relevant literature research mainly focuses on the construction and management of entities such as transmission lines, converter stations, and substations. The practice of ultra high voltage construction is the foundation of management theory and technological innovation.

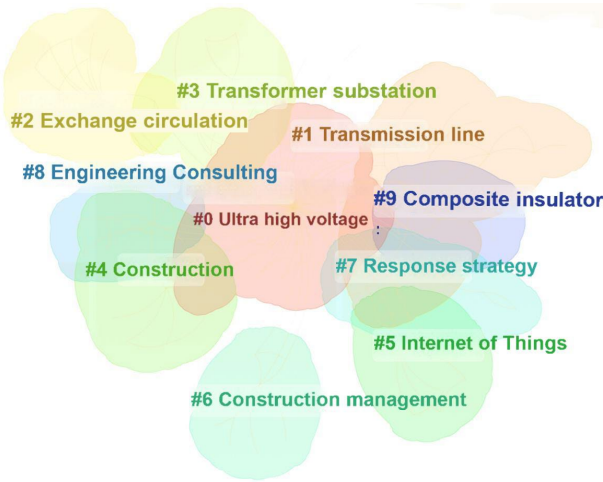


Fig. 3. Knowledge graph of keyword clustering in literature.

4 Measures to improve the management of ultra high voltage engineering

Firstly, focus on quality and strengthen quality control throughout the entire process. Prioritize prevention, strictly control design quality, optimize design processes, and ensure first-class design, technology, and quality. Establish a standardized system for equipment quality management, implement supervision and supplier evaluation, refine daily management, and optimize installation quality control. Carry out special activities to improve the quality of construction and civil engineering, strengthen design quality control, construction quality control, material quality control, and inspection and testing control, promote the continuous improvement of civil engineering quality, and lay the foundation for creating high-quality projects.

Secondly, strengthen the foundation of safety and reduce safety risks from the source. Implement the concept of "great security", establish systematic thinking,

strengthen problem orientation and scientific coordination, and achieve security goals. Establish a three-level safety management system, strengthen the safety responsibility of all employees, and build a solid foundation for safety. Strengthen safety education and training, improve the level of mechanized construction, and implement full coverage of safety control. Optimize design, material, and construction management, manage risks throughout the entire process, strengthen hidden danger investigation and anti violation management. Establish a closed loop of inspection and evaluation, combine self-evaluation with external supervision, continuously improve safety management, and ensure the efficient progress of engineering safety.

Finally, analyze the influencing factors and optimize the management mode of ultra high voltage construction. Optimizing the management mode of ultra high voltage construction requires consideration of factors such as technological innovation, refined management, environmental protection, and economic viability. Adopt a comprehensive strategy, strengthen early planning and demonstration, and ensure project feasibility and social acceptance. Promote refined management and use digital means to improve management efficiency and transparency. Increase investment in technological innovation and research and development, and break through key technological bottlenecks. Pay attention to cost control and resource allocation optimization to improve economic efficiency.

5 Conclusion

This article analyzes the practical significance of using bibliometric methods to analyze the research hotspots and trends in ultra high voltage engineering management. Using CiteSpace software, set the search topics as "ultra high voltage" and "management", select literature published in CNKI from 2014 to 2024, and construct a knowledge graph of ultra high voltage engineering management research. Through bibliometric research, it was found that the main research institution for ultra high voltage engineering management is the power grid company. The most frequently occurring keywords are converter stations, transmission lines, construction management, engineering construction, quality control, safety management, and substations. The keyword clusters include nine categories: transmission lines, converter stations, substations, and construction.

The research conclusions of this article can guide the management of ultra high voltage engineering in the unconventional development stage. The research mainly analyzed the literature published in the CNKI database, with a focus on engineering practices in China, and failed to integrate and analyze the literature published in other databases. Next, we can consider further expanding the scope of our research by analyzing literature published in databases such as Web of Science, and examining the research hotspots and trends in ultra high voltage engineering management from an international perspective.

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