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Research on Engineering Technological Innovation and Risk Management Strategies in Electric Power Construction

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Abstract: This article focuses on electric power engineering and expounds the development characteristics and applications of new electric power engineering technologies, including technologies such as smart grids and digital design platforms. It explores the identification and classification of risk elements in electric power engineering and analyzes the deficiencies of traditional risk assessment methods. It introduces the applications of new technologies such as intelligent sensor networks in risk management, proposes a dual-driven model of technology and management, and looks forward to the application prospects of artificial intelligence and blockchain technologies.

Keywords: Electric power engineering; Technological innovation; Risk management

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1. Introduction

With the increasing demand for energy transformation, the white paper "China's Energy Development in the New Era" released in 2020 emphasized the importance of energy technology innovation and risk management. The intelligent grid technology, digital design platform, and new energy access technology in the field of power engineering are constantly developing, while progress has also been made in BIM full lifecycle management, IoT monitoring technology, and so on. These technological innovations not only improve the efficiency and quality of power engineering, but also bring new risks, such as design defects, construction safety, equipment failures, and environmental factors. Therefore, studying engineering technology innovation and risk management strategies in power construction is of great significance.

2. Current status of technological innovation and development in power engineering

2.1. Development characteristics of new power engineering technology

New power engineering technologies, such as smart grid technology, digital design platforms, and new energy access technology, have shown many development characteristics. Smart grid technology has achieved intelligent monitoring, control, and optimized scheduling of the power system, improving the reliability and stability of the power grid. The digital design platform utilizes advanced computer technology and software tools to accurately model and virtually design power engineering, effectively reducing design errors and improving design efficiency. The new energy access technology adapts to the needs of energy transformation, solves the intermittent and fluctuating problems of new energy generation, and ensures the stable access and efficient utilization of new energy electricity [1]. The innovative breakthroughs in these technologies not only promote the progress of power engineering technology but also significantly improve construction efficiency, laying a solid foundation for the sustainable development of the power industry.

2.2. Key technological breakthrough direction

BIM full lifecycle management has made certain progress in power engineering, covering various stages from design, construction, to operation, which can effectively improve engineering efficiency and quality. By creating a three-dimensional information model, collaborative work among all parties involved can be achieved to detect and solve potential problems in advance. The Internet of Things monitoring technology has also made progress, which can monitor the operating status of power equipment in real time, such as temperature, humidity, and other parameters, providing a basis for equipment maintenance and management. The application of new insulation materials is another key direction [2]. These materials have better insulation performance and mechanical strength, which can improve the reliability and safety of power equipment, extend its service life, and have broad application prospects in the fields of high voltage, ultra-high voltage, and other power engineering.

3. Existing problems in the risk management of power engineering

3.1. Identification and classification of risk factors

The identification and classification of risk factors in power engineering are key to risk management. From the perspective of design defects, unreasonable design may lead to unstable operation of the power system, such as an unreasonable line layout, increasing the risk of faults [3]. In terms of construction safety, violations by construction personnel and inadequate safety protection measures may lead to accidents. Equipment failure is also an important risk factor, as equipment aging, poor quality, and other factors can easily cause power outages. Environmental factors cannot be ignored. Adverse weather conditions may damage power facilities, and complex geographical conditions increase construction difficulty and risks. By constructing a risk identification framework from these four dimensions, it is possible to comprehensively and systematically identify the risk elements of power engineering, providing a foundation for subsequent risk assessment and management.

3.2. Defects in the current risk management system

Traditional risk assessment methods are plagued by significant lag and are ill-equipped to adapt swiftly to the ever-increasing complexity of the power engineering environment and the rapidly evolving technical demands. These methods often rely on outdated evaluation indicators and models that fail to accurately reflect the current risk landscape, leading to potential misjudgments and inadequate risk mitigation strategies. Furthermore, the integrity of existing emergency plans is compromised due to their lack of comprehensive consideration for a wide range of unexpected scenarios. This deficiency results in insufficient response measures when these plans are implemented in real-world situations. Additionally, the current risk management system is severely lacking in research on the risk transmission mechanism [4]. Without a clear understanding of how risks propagate through different links in power engineering and the specific impact modes they adopt, it becomes nearly impossible to effectively prevent and control risks at their source. Consequently, this not only increases the likelihood of risk occurrence but also exacerbates the potential harm that these risks can inflict on power construction projects.

4. The impact mechanism of technological innovation on risk management

4.1. The positive risk control effect of technological innovation

4.1.1. Risk warning capability of real-time monitoring technology

Intelligent sensor networks, as a real-time monitoring technology, have proven to be highly effective in providing robust risk warning capabilities in power construction projects [5]. By strategically placing numerous sensor nodes throughout the construction environment, these networks are able to collect real-time data from key construction areas and critical links. The data gathered encompasses a wide range of parameters essential to the construction process, including temperature, pressure, stress, and more. When abnormal fluctuations are detected in these data streams, they serve as an early indication of potential construction quality deviations or emerging risks. Leveraging advanced data analysis algorithms, these anomalies can be swiftly and accurately identified, triggering timely warning signals. Armed with this critical information, construction management personnel are empowered to take immediate action [5]. They can adjust construction processes, enhance quality control measures, or implement other corrective actions to effectively mitigate risks and prevent their escalation. This proactive approach not only enables real-time monitoring but also ensures active risk prevention and control, significantly enhancing the safety and reliability of power construction projects.

4.1.2. Controllability of risks brought by standardized processes

Prefabricated assembly technology, as a standardized process, significantly enhances risk controllability in power construction. By completing the production of most components in a stable factory environment, this technology effectively reduces the risk of quality instability that is often caused by complex and unpredictable construction site conditions [6]. The standardized nature of prefabricated assembly ensures that the specifications and quality of components are more uniform, which not only facilitates smoother installation and debugging during the construction process but also minimizes delays and safety risks associated with mismatched components. Moreover, the application of prefabricated assembly technology helps to reduce hazardous work processes such as wet and high-altitude operations on construction sites. This further mitigates the personal safety risks faced by construction personnel, thereby improving the overall safety and reliability of the entire power construction process. In summary, prefabricated assembly technology plays a crucial role in enhancing the controllability of risks and ensuring the smooth progress of power construction projects.

4.2. New risks arising from technological iteration

4.2.1. Operational risks arising from technological complexity

As technological innovation progresses, power construction projects are increasingly confronted with new risks stemming from the complexity of advanced technologies. One prominent example is the emergence of network security risks due to the development of smart grid technology [7]. The intricate nature of modern power systems introduces a range of operational challenges. Firstly, the construction process becomes more convoluted, with a significant increase in the number of operational steps required. This complexity heightens the likelihood of human errors. For instance, during the installation and debugging of sophisticated power equipment, even minor mistakes can have severe consequences, potentially leading to equipment damage, project delays, or even safety incidents. Secondly, the growing sophistication of smart devices raises the operational threshold, placing higher demands on the quality and capabilities of construction personnel. Workers are now required to possess a broader range of professional knowledge and skills to effectively manage and operate these advanced systems. If the personnel do not meet these new requirements, they may struggle to operate intelligent equipment correctly, thereby increasing the risk of errors and subsequent complications. Addressing these operational risks requires not only enhanced training for workers but also the development of more robust error-prevention mechanisms.

4.2.2. Compatibility risks of multi-system integration

With the innovation of power construction engineering technology, compatibility risks are faced in the process of multi-system integration. There are differences in interface standards between different technical modules, which may lead to system conflict issues [8]. For example, in the power system, when integrating new intelligent monitoring systems with traditional power transmission systems, data transmission may encounter errors or interruptions due to inconsistent interface standards, which can affect the normal operation of the system. This compatibility risk not only leads to unstable power supply, but may also cause a series of safety issues such as equipment damage, personnel injury, etc. Therefore, in the process of technological innovation, it is necessary to fully consider the compatibility issues of multi-system integration and develop corresponding risk management strategies to ensure the smooth and safe operation of power construction projects.

5. Risk management strategies in the context of smart grid

5.1. Construction of a dynamic risk management model

5.1.1. Risk assessment system based on digital twins

Building a dynamic risk management model is crucial in the context of smart grids. The risk assessment system based on digital twins can establish a three-dimensional dynamic risk assessment model by integrating BIM and GIS technology [9]. Through the 3D modeling capability of BIM and the spatial analysis capability of GIS, the physical structure and geographical location information of power grid facilities can be accurately presented. This model can obtain real-time power grid operation data and simulate risk conditions under different working conditions. By utilizing digital twin technology, a virtual model corresponding to the actual power grid system is created to achieve dynamic monitoring and evaluation of risks. By continuously updating the virtual model and synchronizing it with the actual system status, potential risks can be identified in a timely manner, providing a scientific basis for the formulation and adjustment of risk management strategies.

5.1.2. Dynamic adjustment mechanism for risk warning threshold

In the context of the smart grid, constructing a dynamic risk management model requires considering the dynamic adjustment mechanism of risk warning thresholds. An intelligent warning algorithm that considers real-time changes in environmental parameters can be designed. By monitoring environmental parameters in real-time, such as temperature, humidity, wind speed, etc., these data can be input into the algorithm. The algorithm evaluates risks in real-time based on preset rules and models. When the risk level exceeds the normal range due to changes in environmental parameters, the warning threshold can be automatically adjusted. This dynamic adjustment mechanism can more accurately reflect the actual risk situation and avoid misjudgments or omissions caused by fixed thresholds. At the same time, this mechanism should be continuously optimized by combining historical and real-time data of power grid operation to improve the effectiveness and accuracy of risk management [10].

5.2. Technical risk management safeguard measures

5.2.1. Comprehensive technical talent training system

In the context of the smart grid, a comprehensive technical talent training system is crucial. On the one hand, attention should be paid to the imparting of engineering technology knowledge, including power technology and information technology related to smart grids, so that talents have a solid technical foundation and can cope with complex technological environments. On the other hand, knowledge of risk management is indispensable, covering risk identification, assessment, and response strategies. During the training process, teaching should be combined with practical cases to enable talents to understand the relationship between technology and risk in practice. At the same time, encourage talents to participate in practical projects, exercise their technical and risk management abilities in the projects, so that they can quickly adapt to the work requirements in the smart grid environment, and provide strong talent support for technical risk management.

5.2.2. Construction of technical application standards and specifications

In the context of the smart grid, the construction of technical application standards and specifications is crucial. It is necessary to establish quality control standards for the application of new technologies in power construction, clarify the qualified range of various technical indicators, and ensure the stability and reliability of technical applications. At the same time, the operating standards should cover in detail the construction process, equipment operation methods, personnel safety protection, and other aspects to ensure the standardization and safety of the construction process. Standardized construction should be combined with the characteristics of smart grids, fully considering the compatibility between new technologies and existing systems, as well as the potential risk factors that may arise. By strictly adhering to standards and regulations, constraining the application process of technology, reducing the risks caused by non-standard use of technology, improving the quality and efficiency of power construction, and providing strong support for the stable operation of smart grids.

5.3. Typical engineering practice verification

5.3.1. Risk management case of ultra-high voltage transmission projects

The ultra-high voltage transmission project faces various risks, such as high technical difficulty and significant environmental impact. Taking a certain ultra-high voltage transmission project as an example, an intelligent monitoring system is used for risk management. The system monitors the status of the line in real time, including parameters such as temperature and tension. When an abnormality occurs, it can be quickly alerted to. For example, during an extreme weather event, the system promptly detects an abnormal tension in a certain section of the line, and the staff takes quick measures based on this to avoid damage to the line. Meanwhile, the intelligent monitoring system can also monitor the construction process to ensure compliance with regulations and reduce safety accidents. Through this project practice, the effectiveness of the intelligent monitoring system in risk management of ultra-high voltage transmission projects has been verified, providing references for other similar projects.

5.3.2. Risk management plan for distributed energy access

The integration of distributed energy into the smart grid faces many risks and requires the development of effective disposal plans. From a technical perspective, it is necessary to strengthen the research on monitoring and control technology for distributed energy access points to ensure their stable access. For example, advanced sensor technology is used to monitor parameters such as power quality and power fluctuations in real-time, in order to adjust them in a timely manner. In terms of management, establish a sound approval and supervision mechanism for distributed energy access, strictly review its capacity, location, etc., to avoid causing excessive impact on the power grid. At the same time, emergency plans should be developed to quickly isolate the source of faults or abnormal situations, ensuring the normal operation of other parts of the power grid. It is necessary to strengthen the training of relevant operators and improve their ability to cope with the risks of distributed energy access.

6. Conclusion

This study systematically explores engineering technology innovation and risk management strategies in power construction. By summarizing the interaction patterns between the two, a technology management dual wheel drive control mode is proposed. Research has found that there are currently shortcomings in intelligent algorithm optimization and cross-domain risk transmission mechanisms. In terms of technological innovation, although some progress has been made, there is still room for improvement. In terms of risk management strategy, it is necessary to further improve the response mechanism for complex risks. Looking ahead, artificial intelligence and blockchain technology have broad application prospects in the risk management of power engineering. Artificial intelligence can improve the accuracy of risk prediction, while blockchain technology can enhance information transparency and security. The combination of the two will bring new opportunities and development directions for engineering technology innovation and risk management in power construction.

Disclosure statement

The author declares no conflict of interest.

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