



Innovative exploration on the electricity safety management system for high-rise buildings based on the trinity of government, power utility and users

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Abstract. As the economy grows, there are more high-rise buildings which leads to the issues with electricity safety. This paper focuses on the energy consumption characteristics of high-rise buildings and common electrical hazards, devoting to the current standardization of high-rise building electricity at home and abroad. The government strategies about the power energy nowadays are discussed, to strengthen the management of high-rise buildings electrical safety.

Keywords: High-rise buildings; Standardization; Electricity hazards; The trinity of government, power utility and users; Management system

1 Introduction

In recent years, with the rapid development of urbanization, the shortage of land supply in large cities has forced buildings to higher places. High-rise buildings have brought a modern look to the city, providing the residents with a more comfortable and convenient environment. However, the complex characteristics of high-rise buildings have also brought greater challenges to the electricity safety management. According to data by the China National Fire and Rescue Administration, there are a total of 17,000 high-rise building fires were reported and the number of casualties was 512 in 2022, an increase of 276% and 14.9% compared to 2021, where was mainly concentrated around residential places. The power industry is closely related to our lives, and electricity safety is mostly important. There is an urgent need to the management system for high-rise buildings electricity safety.

2 Research Status of High-Rise Buildings Electricity Hazards

Many researches have been done at home and abroad on how to deal with the risks of high-rise buildings electricity. Reference [1] studies the dilemma of electrical safety management under the background of power system reform, proposing to establish a tripartite electrical safety management of government, power utilities and users. Reference [2] studies the structure of the safety management system of power utilities or enterprises in China and Europe, discussing their differences. Reference [3] and [4] have the conducted researches on electrical fire hazards in high-rise buildings from the managerial side, and put forward the fire protection measures. Reference [5] studies the applicability and feasibility of safety risk management system for power engineering construction based on the big data. Reference [6] studied the different fire causes in residential buildings and commercial buildings. Reference [7] describes the America National Fire Protection Association standards on how electrical maintenance processes are properly operated to ensure safe use of electricity. Reference [8] analyzes the types of electricity consumption in high-rise buildings and provides design ideas and basis from the design perspective. Reference [9] and [10] proposes to realize online monitoring and cause identification of building electrical fires through the Internet of Things technology to deal with building electrical fires. Reference [11] studies the interaction between different roles in security management and explores the application of game theory in the process of security management. Reference [12] proposes a comprehensive assessment model for dynamic risk of electrical fire in high-rise buildings based on Bayesian network and variable fuzzy set theory, and verifies its effectiveness through examples.

3 High-Rise Building Electricity Safety Overview

3.1 Definition of High-Rise Buildings

High-rise buildings, which the general limits of the height are exceeded, the definition of which are also different according to different standards, referring to the residential buildings higher than 27m and non-single-storey public buildings higher than 24m. Buildings lower than 100m are high-rise civil buildings, while buildings higher than 100m are extra high-rise buildings. High-rise buildings are classified by use: residential buildings, office buildings, commercial buildings and so on.

3.2 Characteristics and Types of Electricity in High-Rise Buildings

Compared to traditional buildings, high-rise buildings have a larger vertical spatial span, more supporting electrical facilities, and higher power uses. Therefore, the characteristics of the electrical system in high-rise buildings are high load density, high reliability requirements for power supply, various types of equipment and more power uses. The types of equipment include lighting, air-conditioning, elevators, water pumps,

fans, fire services and other living facilities and special electricity ones. From a spatial perspective, the electrical safety of high-rise buildings includes: supply side safety and user side safety. From a temporal perspective, the electrical safety of high-rise buildings includes: the planning of electricity to be into operation and the management of electricity in operation.

3.3 Analysis of Electrical Hazards in High-Rise Buildings

The electrical hazards in high-rise buildings are mainly about power supply configuration, equipment status, operation management and emergency response. Unreasonable or defective power supply configuration may directly cause accidents or reduce risk resistance. Equipment aging, damage or improper maintenance, non-standard customer operation management, misoperation and overload may directly cause accidents. If the emergency management of accidents is not in place, there is a risk of expanding the scope of accidents and increasing losses. Through research in several regions of China, it was found that the electrical safety hazards in high-rise buildings are often concentrated in missing power supply configuration, improper use and maintenance between power wells, insulation layer damage caused by aging power supply lines and equipment, and weak awareness of electrical safety among residents. The most feedback situations are classified and summarized in Table 1.

Table 1. The list of electrical hazards in high-rise buildings

Types	The details
Power supply	<p>The important loads of Class I and Class II high-rise buildings are single power supply and non-dual circuit power supply.</p> <p>The user's low-voltage important equipment has not been well evaluated, and switching boxes have not been set up for important loads to ensure power supply equipment.</p>
Equipment status	<p>Damaged or incomplete safety and protective facilities in the distribution room, poor ventilation and lighting conditions.</p> <p>The installation of the busbar is too tight, the wiring inside the cable junction box is loose, and there is obvious heating.</p> <p>Improper connection of weak current, small wire diameter on the front line of the meter, and detachment of the circuit slot board.</p>
Operation management	<p>The on duty electricians in the distribution room are not properly configured, and the equipment is not maintained.</p> <p>Residential electricity is not equipped with leakage protectors, and high-power electrical appliances are used in a centralized manner.</p> <p>The distribution room and hallway are piled up with debris, and the fireproof mud is not sealed.</p>
Emergency response	<p>No emergency power generation vehicle access point configured, unable to supply power to security loads through the power generation vehicle.</p>

Failure to carry out emergency plans and drills for related accidents on schedule.

4 Power Standardization Technology for High-Rise Buildings

4.1 The Analysis of Electrical Standardization for High-Rise Buildings

The power supply standards for high-rise buildings involve aspects such as power load calculation, power supply mode selection, cable laying, and safety requirements. In order to improve the operational efficiency and management level of the power system in high-rise buildings, achieve safe, stable, and economical operation of the power system, relevant standards have been formulated internationally and in the power industry based on the different characteristics of high-rise buildings, providing a basic standard basis for the design and acceptance of distribution facilities in residential high-rise buildings. Some standard related content is shown in Table 2.

Table 2. Some of the electrical standards for high-rise buildings

Title	Country	The details
《Code for design of 20kV and below substation》 (GB 50053-2013)	China	The construction regulations that must be followed for the installation of non-oil filled electrical equipment in the underground of multi stories or high-rise buildings in distribution substations and substations.
International Building Code 2015 (IBC 2015)	America	Specify the relevant construction requirements for high-rise buildings, including electricity related standards
Fire safety in the design, management and use of buildings-Code of practice (BS 9999:2017)	England	Stipulate fire and electrical safety regulations for high-rise buildings, and specify requirements for fire resistance rating of high-rise buildings
《Code for design electric power supply systems》 (GB 50052-2009)	China	The ultra high-rise buildings and Class I high-rise buildings should use dual power supply, while Class II high-rise buildings often use dual circuit power supply.
《Code for fire protection design of tall buildings》 (GB 50045-2005)	China	Class I high-rise buildings should be powered according to Level 1 load, and Class II high-rise buildings should be powered according to Level 2 load requirements.
Electrical installations of buildings--Part 4-41: Protection for safety--Protection against electric shock (JIS C60364-4-41-2006)	Japan	The high-rise buildings must meet relevant electrical safety protection and shock protection requirements.

《Code for design of 20kV and below substation》 (GB 50053-2013)	China	The construction regulations that should be followed for the installation of non-oil filled electrical equipment distribution stations and substations in the basement of multi stories or high-rise buildings.
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Some provinces and cities in China have introduced a series of regulations for power supply and distribution facilities in residential communities. In all, the local standards are more stringent than the national standards, while the standards in the east are more stringent than those in the west. At the same time, generally high-rise buildings have called for two power lines, what's more, the local departments of housing construction have also made detailed regulations on fire pumps, elevators, backup power sources, ventilation, flood prevention and other aspects for high-rise buildings.

4.2 Measures for Electrical Standardization for High-Rise Buildings

Electrical standardization for high-rise Buildings refers to the compliance with the standards in the design, construction, operation and other stages of high-rise buildings to ensure the safe, stable and efficient operation of the power system. In the design stage, fully consider the building structure, equipment layout, load demand and other factors to ensure the rationality and economy of the power system design; In the construction phase, pay attention to quality management and safety management; In the operation phase, carry out good equipment operation and maintenance, safety inspection, fault handling and other work. The implementation of standardization is of great significance to improve the reliability of high-rise building power system, reduce operating costs and improve service quality. At present, the high-rise building power standardization system still needs to be improved, and the "Low-voltage electricity Safety Inspection Guide" is also being studied and compiled to standardize the regular inspection content of high-rise building electrical safety.

5 Strategies of Government Management for High-Rise Buildings

The government plays a vital role in the safety management of electricity consumption in high-rise buildings. In order to ensure the safety of electricity consumption of high-rise buildings, the government conducts comprehensive control over the construction process of high-rise buildings through the approval, acceptance and other links at different time nodes.

Firstly, the government has established strict electricity safety regulations and standards, comprehensively regulating the electrical facilities, wires and cables, and power equipment of high-rise buildings to ensure their safety, reliability, and efficiency. For example, the selection of wires and cables must comply with relevant standards to prevent fire accidents caused by quality issues of wires and cables. Secondly, the housing and construction management department regularly conducts electrical safety inspections on high-rise buildings, including the physical condition of equipment and the

operational status of electrical systems. Thirdly, the government should establish a sound emergency response mechanism to minimize the losses caused by accidents, including establishing a dedicated emergency response team, developing detailed emergency plans, and equipping necessary emergency equipment. What's more, the government has established a sound regulatory mechanism and evaluation system to monitor and evaluate the electricity safety status of high-rise buildings in real time. The Chinese government has implemented hierarchical control measures and issued relevant policy documents on low-voltage electricity management for high-rise buildings from the national to local levels, as shown in Table 3.

Table 3. The Chinese government has issued policy documents related to low-voltage electricity management in high-rise buildings

Government level	Title
Nation	“Electricity Reliability Management Measures” (Provisional)
Province	“Jiangsu Province Residential Property Fire Safety Management Regulations”
Prefecture	“Notice on the Investigation and Rectification of Hidden Dangers in Grid Related Equipment of Power Users in the City”
Prefecture	“Notice on the Bureau of Industry and Information Technology of Quanzhou on Strengthening the Reliability Management of Power Facilities”
Prefecture	“Special Management Plan for Power Safety Hazards in Baodi District”
County	“Notice on the Development and Reform Commission of Kuitun on Strengthening Electricity Safety Management”
County	“Fengxian Safe Electricity "Village Grid Construction" Benefiting the People Working Plan”

6 The Management System Based on the Trinity of Government, Power Utilities and Users

6.1 Establish the Tripartite Electricity Safety Management System

The power safety of high-rise buildings is related to the safety of life and property of power users and the safety and stability of enterprise production. It is an important support to construct a tripartite linkage safety management mechanism of the mechanism construction subject of government departments, the technical service subject of power supply enterprises, and the responsibility subject of power users. In this system, the government plays a dominant role. On the one hand, through legislation and regulations to regulate the order of electricity consumption, supervise the power supply enterprises and guide the power users to use electricity safely; On the other hand, through the means of publicity and education, the popularization of electricity safety knowledge to the vast number of power users is an overall role. Power supply enterprises mainly perform good functions, support the relevant legislative work of the government,

respond to the needs of users and provide high-quality services, and participate in the handling of specific security risks. Power users should clarify the positioning of the responsible subject, as a direct user must use electricity safely and standardize electricity. The relationship of the tripartite electricity safety management system is shown in Figure 1.

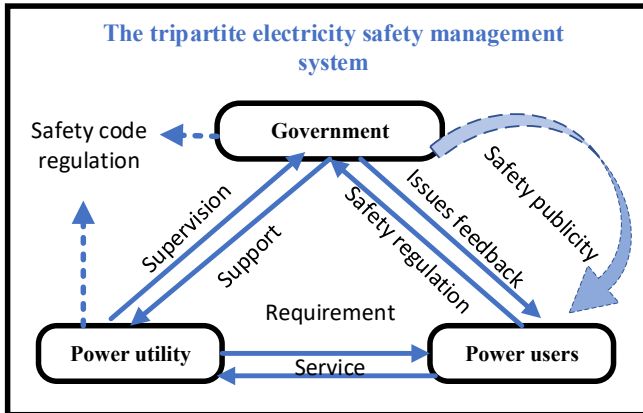


Fig. 1. The relationship of the tripartite electricity safety management system

6.2 The Construction and Improvement of Electricity Safety Management Mechanism Leading by the Government

First of all, the government departments should take the lead in introducing or revising relevant legislative documents and technical standards to provide the most fundamental guarantee for mechanism construction, such as the revision of the "power supply business Rules" clearly put forward the safety of high-rise buildings. Second, the government should play a leading role, coordinate resources of various parties, and formulate long-term special management measures. The third is to strengthen the whole process supervision of high-rise building electricity safety, urge every corresponding responsible party, to ensure that the rectification is timely and in place. What's more, the extensive and in-depth publicity activities for users to enhance the awareness of public safety electricity, combined with realistic accidents will be more intuitive and effective, it is proposed to set up July as high-rise building safety electricity month, and combined with safety production day, safety science popularization day and other theme education activities, around the theme of safe electricity, electrical fire prevention and other pre-warnings.

6.3 The Main Responsibility to Enhance Safety Awareness That Clarified by the Power Users

According to China's "Civil Code", "Production Safety Law", "Power Law" and other relevant laws and regulations, residential users are the main body of the responsibility for electricity safety, need to have basic knowledge of electricity safety, equipment in

public areas, shall not be changed without permission, stacking debris occupy the power distribution room and other behaviors, shall not damage the legitimate rights and interests of others and social public interests. For the equipment such as elevators and pumps commonly used in high-rise buildings, the user management such as property management should understand the structure, working principle and safe operation procedures of power facilities and equipment, avoid possible risks during use, and do a good job in daily electrical hazard control.

6.4 The High-Quality Electricity Safety Inspection Services That Provided by the Power Utilities

power utilities provide the better electricity safety services by advanced technologies. In terms of security risk perception, comprehensive use of intelligent iot energy meters, electricity safety risk identification modules, energy controllers and other monitoring and sensing systems. A unified intelligent platform for safe electricity management is established by combining intelligent power subsystem, smoke control system, fire water subsystem, fire equipment power subsystem, fire gate system, fire equipment management subsystem and video monitoring subsystem. The intelligent power subsystem can be connected to electrical fire, lone arc, electrical fire host, arc extinguishing protector and wireless temperature detector to produce linkage effect, and improve the level of intelligent management of electricity safety. More details are shown in Figure 2.

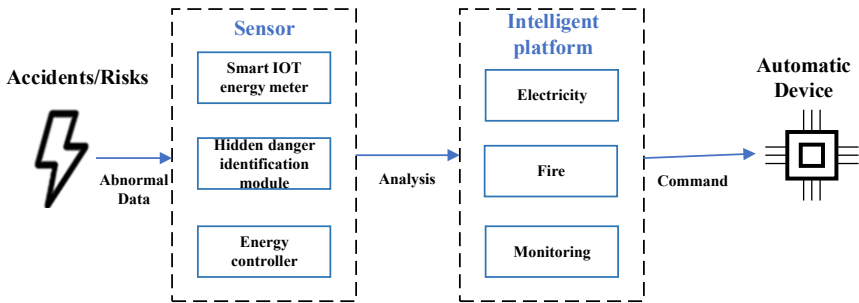


Fig. 2. Power utilities electrical safety service technology system

Meanwhile, promote the occupational skills training and qualification certification of power safety management personnel, carry out the knowledge training of power safety laws and regulations for personnel engaged in production of high-rise buildings, strengthen the qualification certification of staff engaged in safety management, improve the management quality and service ability of professionals, and provide talent support for high-rise building power safety management services.

7 Conclusion

With the rapid development of social economy, the number of high-rise buildings is still increasing, in order to effectively deal with the relevant electricity safety risks, we need to establish and improve the high-rise building electricity safety risks management system, which requires the government, power enterprises and power users to work together. Based on the analysis of power safety hazards of high-rise buildings and the existing power standard technology and government management measures, this paper proposes a new tripartite linkage management mechanism for power safety hazards of high-rise buildings with government-led construction, users' clear responsibilities and power enterprises' support services, so as to more effectively ensure the power safety of high-rise buildings and better protect the life and property safety of residents.

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