Discussion on Strengthening Integrated Construction of Low Voltage Electricity Safety Management

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Abstract. With the development of society, the low voltage electricity consumption environment is becoming increasingly complex. Related electrical safety issues are also increasing day by day. In order to improve the safety management level of low voltage electricity consumption, this article analyzes the background of low voltage electricity safety management, explains the current situation of low voltage power consumption management in the new power system, and finally proposes the construction of an integrated management system for low voltage electrical safety. It puts forward specific construction plans from the perspective of optimizing on-site process management and introducing intelligent operations, to provide solid guarantee for the safety management of low voltage power consumption.

Keywords: low voltage electricity; Safety management; Integration; Process management; Intelligent operation.

1 Introduction

In recent years, due to the rapid development of the economy and society, as well as advancements in electrical technology, there has been a noticeable increase in various electrical loads, leading to a changing low voltage electricity environment. While electricity brings us convenience, it also poses significant risks. According to the 2023 statistics on China's fire situations, there were a total of 745,000 reported fires throughout the year, resulting in 1381 deaths, 2063 injuries, and direct property losses of 6.15 billion yuan, with 31.2% attributed to electrical fires. Notably, the recent public concern has been on several fires caused by the spontaneous combustion of electric vehicle charging, with 21,000 electric vehicle fires reported in China in 2023, marking a 17.4% increase from 2022. The low voltage electricity management situation is concerning, leading to an urgent need to enhance the safety management level of low voltage electricity consumption.

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2 Research status of low voltage electricity safety

Many researches have been done at home and abroad on improving the safety of low voltage electricity consumption. Reference [1] suggests establishing a three-in-one management mechanism for identifying safety hazards in high-rise building electricity consumption. Reference [2] explores the use of data mining technology to develop an electrical fire monitoring system for detecting abnormal residual currents to mitigate electrical fires. Reference [3] proposes a novel voltage compensation mechanism to address the control problem of DC microgrid in a distributed manner. Reference [4] introduces a demand response management platform for low voltage users based on blockchain technology. Reference [5] designs a low voltage intelligent management system for distribution networks by integrating multi-source data. [6] investigates a new method for series arc fault detection in low voltage lines under the background of power Internet of Things technology. Reference [7] suggests establishing a new monitoring method to improve the perception ability of electricity safety states on the customer side. Reference [8] proposes a electricity consumption safety perception module conforming to the technical specification of the energy meter's expansion module in the Internet of Things. Reference [9] examines the use of fuzzy analytic hierarchy process for electrical safety risk assessment in the electricity distribution industry. Reference [10] introduces a method that integrates clustering algorithms and Bayesian networks to identify the operational status of electrical appliances. Reference [11] studies the structure of the safety management system of power grid enterprises in China and Europe, comparing and evaluating the two systems. Reference [12] examines the applicability and feasibility of a safety risk management system for power engineering construction within the context of big data.

3 Background

3.1 Policies and regulations

In China, the low voltage electricity management work is mainly based on the Civil Code of the People's Republic of China, the Electricity Law of the People's Republic of China, the Regulations on Supply and Utilization of Electricity, and other relevant laws. In 2023, revisions were made to the "Electric electricity Business Rules", adding content to further protect the rights and interests of electricity users, including specifying charging facility construction requirements, dual power supply configuration in high-rise residential buildings, and requirements for flood prevention and drainage in distribution facilities. In addition, some local government regulations in China provide more specific guidance on low voltage electricity management work.

3.2 "Double carbon" and distributed energy

In September 2020, China proposed the "double carbon" targets, which aims to peak carbon dioxide emissions before 2030 and achieve carbon dioxide or greenhouse gas

emissions neutrality by 2060, through various forms of energy conservation. Against this backdrop, the transformation of energy structure, distributed new energy consumption, electric vehicle charging and discharging, and energy storage access have posed new requirements for the improvement of low voltage power service quality, bringing new challenges to low voltage electricity management work.

3.3 Higher electricity demand

As we enter a new stage of development, people's longing for a better life has shifted from "whether there is" to "how good it is". There has been a profound change in the types of electricity customers and energy consumption patterns, with an increasing demand for diverse, customized, and interactive services. There is a growing emphasis on the convenience, interactivity, and high quality of power supply services, and users are placing higher demands on the quality of power supply services and the basic level of low voltage distribution network.

4 Low voltage electricity safety inspection status

4.1 Standardization work

The management of low voltage electricity primarily focuses on metering devices and power transmission facilities related to customer grids. It entails activities such as on-site and system file verification for low voltage customers, inspection of metering devices and ancillary facilities, and electrical safety inspections. To prevent personal injury, property damage, or abnormal power interruptions during the electricity consumption process, which includes design, installation, operation, and maintenance, relevant standards have been established by the international power industry. For details on some of the standards, refer to Table 1.

Table 1. Some of the electrical standards for high-rise buildings

Title	Country	The details
General guide for safety of electric user (GB/T 13869-2017)	China	The fundamental prerequisites for electrical equipment during the design, production, installation, usage, and maintenance at all stages of the lifecycle ensure electricity safety.
IEEE Guide for Fire Hazard Assessment of Electrical Insulating Materials in Electrical Power Systems (IEEE 1221-1993)	America	This article addresses the fire risks associated with power distribution and electrical systems in settings including industrial, residential, and public buildings.
Distributed energy resources connection with the grid. General requirements (PD IEC TS 62786-1:2023)	England	The technical specifications, connection layout, and equipment selection for the distributed energy system connecting to the distribution network are defined.

General requirements for rural low voltage safety electricity consumption （GB/T 43055-2023）	China	The general requirements for low voltage safe electricity consumption in rural areas, low voltage power lines, and basic requirements for safe electricity consumption in life and production are specified.
Electrical installations of buildings--Part 4-41:Protection for safety--Protection against electric shock (JIS C60364-4-41-2006)	Japan	High-rise structures are required to adhere to the pertinent regulations for electrical safety and protection against electric shock.

4.2 Special inspection work

In China, at present, power supply enterprises primarily conduct special inspection work, taking into account the seasons, important festivals, electricity protection, government requirements, and the needs of high-rise residential buildings, agricultural drainage irrigation, heating enterprises, and other low voltage key electricity customers. This includes inspections for low voltage defaulting power customers such as over-capacity and suspected private start. Special inspections are also conducted in high-risk areas such as employee dormitories, concentrated residential areas, and employee family areas.

4.3 Contents of on-site inspection

The field inspection of low voltage power supply includes two aspects: grid side and customer side. The inspection scope of the power grid side includes the low voltage metering box (cabinet) and the energy meter, transformer, isolation switch, circuit breaker, collection terminal, and its connection wire in the metering box (cabinet). The customer side inspection service scope mainly covers the customer's receiving or sending power device. For the inspection contents of several types of key scenarios, refer to Table 2.

Table 2. The list of electrical hazards in high-rise buildings

Types	The details
High-rise buildings	Power supply and self-provided emergency power supply configuration; Self-provided generator access method and automatic transfer function; Cable channel blocking; Safety protection supplies and tools.
Farm drainage irrigation	Table back wire insulation; Safe distance between wires; Private pull random connection; Customer side leakage protector; Irrigation equipment leakage hazard.
Rural household	Customer-side voltage; Insulation of meter rear line; Supply radius; Customer-owned pole leaning situation; Unauthorized connections by customers.

Coal to electricity	Customer-side voltage; Actual equipment capacity vs. Contracted capacity; Capacitor compensation device; low voltage cables; Leakage protectors; Distribution cabinets; low voltage line layout; Line insulation.
Charging pile	Equipment insulation; Grounding, pile connection situation; Power matching; Insulation protective equipment; Fire extinguishing device; Safety signs; Environmental dryness; Emergency response plan for emergencies; End-level multi-function protection device.
Photovoltaic power generation	Grounding of metal boxes and photovoltaic panels; Lightning protection device; Protection device; Grid-connected devices such as inverters; Energy storage equipment; Power factor on the generation side; Generation efficiency; Grid voltage; Safety protective equipment and work tools.

5 Integrated construction

5.1 Construction of low voltage electricity safety management system

The integrated construction of low voltage electricity safety management system, featuring government guidance, user participation, and proactive enterprise involvement, is being promoted. Government departments are introducing relevant policies, local legislation, and technical standards for low voltage electricity management, and conducting rectification of hidden dangers and source governance. Power supply enterprises are fulfilling their responsibilities for low voltage electricity management, delineating job duties, conducting on-site inspections and governance of low voltage electricity, identifying hidden dangers, and gathering needs. Users are required to clarify their own responsibilities and use electricity safely and compliantly under external publicity guidance.

5.2 Contents of on-site inspection

Prior to inspection, periodic and special plans must be developed for comprehensive assessments of all low voltage users. Special inspections should be dynamically integrated based on seasonal variations, governmental mandates, and territorial conditions, complemented by cross-supervision to ensure reliable technical backing and provide impetus to low voltage consumers in the discovery and management of hazards and defects. Enhancements to the post-assessment system, grounded in the prevailing state of grid management, call for subsequent measures in business, measurement, inspection, service, and power distribution, thus strengthening collaborative efficiency and work quality through appraising the rectification in each domain. The specific connections is shown in Figure 1.

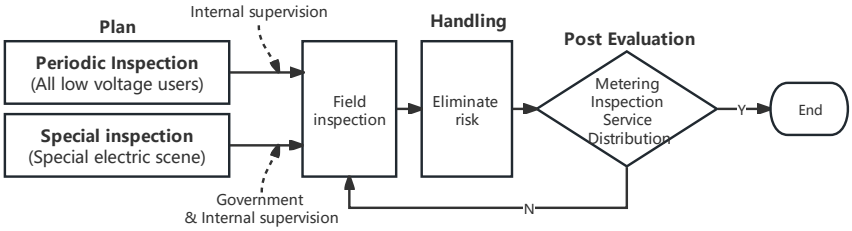

Fig. 1. low voltage electricity inspection process management

Furthermore, reliance on technical systems to advance vocational proficiency and qualification in low voltage electricity management, and widespread undertakings of thematic publicity activities—both online and offline—can effectively elevate the caliber of business and safety consciousness.

5.3 Improve the intelligent operation of low voltage electricity management

On one hand, a wealth of on-site inspection methods and online operational support in low voltage electricity will be available. This involves deep exploration of consumer data on zero live line current imbalances, abnormal power quality, long-term zero power users, and more, with focus on residential high-rise buildings, charging piles, distributed photovoltaic systems, rural electricity, and other load monitoring and hazard analysis, to aid in the identification of key inspection targets among low voltage users and timely discovery of safety risks. Support will also be extended for state inspections of low voltage power. On the other hand, the development of digital safety technologies for low voltage electricity will be pursued, leveraging intelligent IoT energy meters, electricity safety hazard identification modules, energy controllers, and other monitoring and sensing systems to establish a unified intelligent platform for low voltage electricity management. This will furnish convenient tools for on-site inspections, significantly enhancing the intelligence, automation, and informatization levels of low voltage electricity management. The specific operational models is shown in Figure 2.

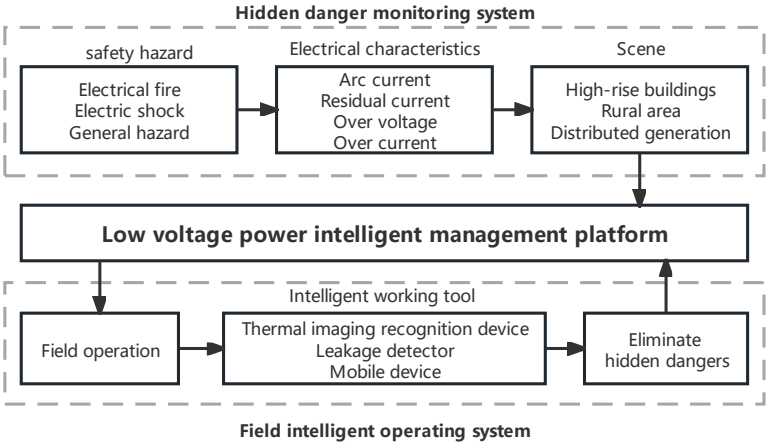

Fig. 2. low voltage electricity management intelligent operation system

6 Conclusion

Society and the economy are undergoing rapid development, and the demands for low voltage electricity safety management are continuously on the rise. This research delves into the overall landscape, current status, and future trends of low voltage electricity management. It identifies prevailing issues and proposes multiple strategies to establish a multi-tiered and systematic low voltage electricity safety management system. This involves enhancing end-to-end control and widely employing intelligent operational technology. These measures aim to meet the requirements of constructing and developing the new power system, achieving high-quality development and service, efficient management, and better safeguarding the safety of residents.

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