Study on Regional Power Grid Emergency Command Mechanism

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Abstract: In China, power grid companies have a primary mandate of ensuring a secure, cost-effective, environmentally friendly, and sustainable power supply. However, recent years have witnessed escalating safety risks within the power grid, including exposure to natural disasters, occupational injuries, and public safety concerns. Considering the Chinese government's strides in developing regional emergency responses and an integrated power grid, there's an urgent need to amalgamate regional emergency resources and initiate the establishment of regional emergency management systems for the power grid. This paper systematically reviews both domestic and international experiences and practices concerning emergency management, specifically in accident response, governmental intervention, and other pertinent facets of power grid management. Additionally, it outlines the requisite measures mandated by the State Grid for emergency management. Drawing from this analysis, the study embarks on designing and researching regional emergency management structures within the power grid. The research identifies: (1) the implementation of regional emergency management within the power grid as a prevailing trend domestically and internationally, aligning with China's comprehensive emergency management plan and the current imperatives of China's power grid emergency management efforts. (2) The criticality of conducting emergency responses within the power grid region, centered around an emergency command center, buttressed by a robust contingency plan system and supported by comprehensive mechanism construction. (3) The necessity for the power grid to establish a four-tier management system encompassing "power grid headquarters, regional branches, provincial companies, and city and county companies," with a specific emphasis on system and mechanism development.

1. Introduction

As the Chinese economy continues to expand, the demand for electricity in China is on the rise. However, the State Grid has encountered numerous risks in recent years, including natural disasters like typhoons, rainstorms, and floods, work-related injuries such as falls from heights and electric shocks, concerns regarding public security and fire safety, and emergencies such as widespread power outages. Consequently, certain provinces or regions have experienced insufficient emergency responses. Currently, the Chinese government emphasizes enhancing emergency management across various industries. Similarly, within the State Grid, efforts are underway to advance integrated development. Given these risks and policies, it becomes imperative to consolidate regional emergency resources within the power grid and prioritize the establishment of regional emergency management systems.

Currently, there's significant international recognition for regional emergency management efforts. Firstly, on the governmental front, various countries have established comprehensive emergency management systems encompassing laws, regulations, organizational structures, emergency teams, and mechanisms [1-4]. These frameworks serve as crucial support for

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implementing emergency management within power grids. Secondly, within power grid emergency response, the United States and Canada have demonstrated success through effective system construction, emergency planning, and drill executions [1-2]. Regarding power grid emergency response, China presently prioritizes addressing large-scale power outages, studying power grid disaster characteristics, and early warning systems [5-6]. Preliminary exploration has been undertaken in establishing integrated emergency commands for regional power grids. However, the development of a comprehensive regional power grid emergency management system remains in its nascent stages. Moreover, regional emergency management for other types of disasters, such as mining incidents [7], has achieved mature development, establishing stable operational modes encompassing legal frameworks, infrastructure development, team establishment, and structural mechanisms. These advancements offer valuable insights applicable to constructing regional emergency frameworks for power grids.

Consequently, this paper systematically consolidates the expertise and methodologies from government emergency management, power grid emergency management, accident emergency management, and related domains, both domestically and internationally. It delineates the specific documentation criteria mandated by the State Grid for emergency management endeavors. Building upon this foundation, the study embarks on designing and researching a regional emergency management system tailored to the power grid. Optimization of key construction areas is undertaken, aiming to furnish a theoretical framework guiding future regional emergency management within the State Grid.

2. International Emergency Management

To bolster regional emergency management within the State Grid, this paper conducted literature research from three focal viewpoints: government-level regional emergency management, power grid-specific regional emergency management, and other forms of disaster-based regional emergency management. International Emergency Management

2.1 Government Regional Emergency Management

The United States, Germany, and Japan have amassed successful experiences in regional emergency management [1, 8-9], primarily evidenced by the following aspects.

1) The implementation of national-level laws and regulations governing emergency management significantly influences the nationwide advancement of emergency protocols. The Basic Law of the Federal Republic of Germany encompasses provisions for disaster relief. Similarly, Japan possesses an extensive legal framework concerning emergency management, including legislation such as the Safety Production Law, Fire Protection Law, and Prevention of Extraordinary Disasters Law.

2) The national emergency management system serves as a crucial foundation for emergency operations, offering essential support for regional rescue efforts.

a) The emergency response system for accidents in the United States operates through a collaborative framework involving federal, state, and local governments, along with private institutions. The Federal Emergency Management Agency (FEMA) shoulders the responsibility for coordinating federal emergency response and rescue efforts. Furthermore, each state and local government maintains its dedicated emergency management agency tasked with formulating and executing local emergency and response strategies. Traditionally, emergency management in the United States has predominantly leaned on local governance, where the majority possess emergency operation centers responsible for coordinating responses, managing domestic crises, and disseminating situational updates.

b) The German federal government is tasked with coordinating inter-state rescue operations to the fullest extent possible. Additionally, it leverages the role of the federal army, rescue teams, and resources in exceptional circumstances. On the other hand, the responsibility of the state government involves direct prevention and management of hazards, development, and implementation of pertinent contingency measures within the incident area. Moreover, it

encompasses the establishment of an efficient system for routine disaster emergency responses within the state.

3) Emergency rescue team.The emergency rescue team plays a pivotal role in accomplishing rescue operations. In the United States, the emergency management team comprises three components: a professional team, part-time personnel, and volunteers. Conversely, the Japanese government has established various specialized regulatory agencies within emergency management, including the Ministry of Health, Labour and Welfare, the Ministry of Economy and Industry, the Ministry of Land, Infrastructure and Transport, and the Public Security and Fire Department, each equipped with specific rescue teams.

4) Mechanism construction. Developing supportive mechanisms is crucial to ensuring the effectiveness of emergency management. In the United States, states and local governments have established relatively comprehensive regional coordination and mutual assistance systems. Germany has established a collaborative mechanism for mutual cooperation facilitated by the Federal Agency for Citizen Protection and Disaster Relief, alongside the Federal Technical Disaster Relief Agency. Japan's emergency system is notably comprehensive, encompassing early warning systems, emergency assistance protocols, public awareness and education initiatives, and international cooperation frameworks.

2.2 Power Grid Regional Emergency Management

The United States, Canada, and France have successfully implemented measures in emergency system construction, emergency planning, and emergency drills within their power grid regions, providing valuable lessons for China to learn from [1-2].

1) United States

a) The emergency response operations in the United States are primarily managed by the Department of Energy, the National Nuclear Safety Administration, and the Federal Emergency Management Agency (FEMA). The Department of Energy has implemented the Comprehensive Emergency Management System for Electric Power, outlining protocols for emergency response, leadership in emergency management, energy crisis procedures, plans for emergencies and assistance, communication protocols, public relations policies, contingency requisites, evaluation and readiness, and plan administration. Additionally, FEMA has formulated and disseminated the Federal Emergency Response Plan, aimed at harmonizing the creation of emergency frameworks between federal and state/local governments. This plan integrates strategies from various federal agencies to prevent and address emergencies, providing guidance to state and local governments for responding to terrorist attacks, disasters, and other emergencies within the National Emergency Management System.

In the realm of emergency response within the power grid sector, diverse power companies in the United States have instituted collaborative management and coordination entities, exhibiting varying contents and structures. For instance, entities like the Northeast Joint Power System have been established. These joint venture companies engage in transmitting and receiving agreed-upon electricity through contractual arrangements, fostering a mutually supportive framework, particularly evident in critical situations, as illustrated in Figure 1.

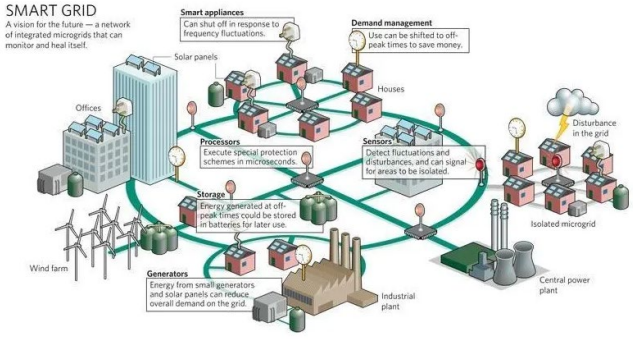

Figure 1 Conceptual map of regional smart grid in the united states.

b) Emergency plan. The development of a contingency plan system for sudden safety incidents in the US power system comprises four distinct yet interconnected stages: prevention, preparation, response, and recovery. These stages form an integrated and evolving process. Prevention involves hazard identification and mitigation. Emergency preparedness encompasses resource readiness, plan creation and refinement, drills, prediction, warning systems, and simulation analysis, aimed at enhancing response capabilities. The response phase involves utilizing emergency resources to minimize the impact of disasters on personal safety, power infrastructure, national security, and societal well-being, initiating relevant rescue measures. Recovery entails actions to conclude emergency situations and restore normalcy.

c) Emergency drills. The US power industry conducts three primary types of emergency drills: desktop drills, functional drills, and practical drills. These drills encompass general emergency exercises for various power system accidents, such as large-scale power outage scenarios. Additionally, specialized emergency drills are conducted for distinct power facilities, notably including frequent large-scale drills for sudden safety incidents in nuclear power facilities.

2) Canada

a) Emergency management system. Under the Canadian Electricity Act, the Department of Energy and independent power operators are designated entities responsible for coordinating market participants to develop emergency plans and ensuring effective management of power emergency incidents. Independent power operators in Canada have established an agency dedicated to emergency plan management, tasked with coordinating and maintaining the emergency plan system over the long term. Regarding regional emergency response, significant emphasis is placed on intra- and inter-regional cooperation. For instance, Ontario, housing Toronto, operates as a protocol area for electricity exchange and operations between Canada and the United States. It maintains mutual support arrangements with both domestic and American power companies.

b) Emergency plan. The development of the emergency response plan system within the Canadian power system involves collaboration among three key entities: the Department of Energy, power generation companies, and independent market power operators. Canada's emergency response plan system primarily encompasses five key elements: analysis of unforeseen safety incidents, establishment of an emergency management support team, operation of an emergency operation center, planning and execution of emergency drills, and ongoing maintenance of the emergency response plan system.

c) Emergency drills. Emergency drills within the Canadian power industry typically encompass three key stages: training, practical inspections, and evaluation. Following the training and practical inspections, the evaluation phase meticulously assesses each aspect of the emergency drill in line with the prescribed guidelines in the emergency drill manual. This evaluation process involves two main aspects: an assessment of participants' engagement during the emergency drill and comprehensive documentation outlining the review content. All involved participants must study and recapitulate their respective roles and actions. Subsequently, the emergency management agency reviews these reports and offers corrective recommendations.

3) France

a) Emergency management system. France's primary focus lies within the realm of nuclear power. The nuclear emergency management system in France operates through the framework of 'two main lines, secondary management, and two decision-making centers.' The two main lines encompass governmental administrative bodies and nuclear power operator units. Secondary management involves national-level institutions comprising the national nuclear emergency coordination agency, the General Administration of Nuclear Safety and Radiation Protection, and the General Administration of Civil Defense. Additionally, it involves local-level institutions primarily consisting of provincial governors, and at the national level, it includes the headquarters of the French Electric Power Company. The operator unit line comprises local-level institutions primarily within nuclear power plants. The two decision-making centers include an administrative center where provincial governors take action to safeguard the public and the environment, and a technical center where nuclear power enterprises manage unit status, protect power plant staff, and

ensure smooth information flow.

b) Emergency plan. Nuclear power holds a central role in France's electricity generation, consequently, emergency management within the nuclear power industry occupies a paramount position in the overall emergency management framework of the French electricity sector. The Nuclear Energy Agency of the European Economic Cooperation Organization has detailed four distinct nuclear power accident scenarios in its nuclear exercise report, each accompanied by dedicated emergency plans.

c) Emergency drills. The establishment of a nuclear emergency response plan system constitutes a crucial element within nuclear emergency management. In France, this system revolves around four primary components: communication, evaluation, planning, and action. French regulations mandate the participation of each nuclear power plant in a national-level nuclear emergency exercise every three years. Annually, France conducts approximately eight national nuclear accident emergency drills, comprising 6-7 simulations focused on nuclear power plant accidents and 1-2 simulations related to other nuclear facility incidents.

2.3 Other Disasters Regional Emergency Management

Regional disaster response strategies applied in other contexts can offer valuable insights for regional power grid rescue operations. This study investigates rescue operations in mining, earthquake, and typhoon-affected areas [7, 10-11].

1) Mines

Given the potential for mass casualties in mining accidents, governments worldwide prioritize emergency management within mining industries. The United States, Australia, Canada, and other nations have achieved significant advancements in establishing systems, teams, and mechanisms for mining emergencies. China's power grid regional emergency rescue efforts can draw valuable lessons from the United States' advanced mining rescue methodologies, particularly in the following areas.

Laws and regulations. The United States has implemented a robust legal framework for mine rescue, exemplified by acts like the Federal Mine Safety and Health Act and the Coal Mine Improvement and New Emergency Response Act, ensuring crucial support for effective mine rescue operations.

Organizational structure. The Federal Mine Safety and Health Administration serves as the principal administrative body overseeing mine emergency management in the United States, holding comprehensive responsibility for mountain safety, health monitoring, and mine rescue operations. To further advance its mission and duties, the bureau has established regional offices across 38 states.

c) Emergency rescue team. ChatGPT

The mining rescue teams in the United States are categorized into four main types according to their nature and funding sources: company-owned teams, cooperative teams, contracted teams, and state government-funded teams.

2) Earthquake. Earthquake emergency response stands as a quintessential example of regional emergency rescue. Notably, international efforts in earthquake rescue have made substantial strides in recent years, offering valuable insights for regional power rescue. Key aspects warranting attention and adaptation include:

Master rescue information in multi-dimensional space

Multi dimensional delivery of disaster relief forces

Multi force cohesive rescue

Diversified and diversified rescue support

Professional rescue techniques

Joint military civilian rescue

3) Typhoon. Typhoons, being formidable and destructive meteorological disasters, annually inflict significant safety losses on the power grid. Japan has achieved remarkable strides in typhoon emergency management, implementing a series of response measures spanning the pre-arrival,

active period, and post-typhoon stages. This systematic approach for prevention and resilience against typhoons offers invaluable experiential insights for establishing regional emergency systems within China's power grid.

a) Refined typhoon warning system

Develop a comprehensive legal system to achieve legal disaster prevention and reduction.

Strengthen grassroots emergency management work and cultivate the self rescue ability of the public.

b) Standardized emergency typhoon response system

Establish a crisis management mechanism and continuously promote the process of rescue and disaster relief work.

Increase the supply of emergency supplies to ensure sufficient and timely supply of rescue supplies.

c) Systematic recovery and reconstruction system

Establish a post disaster reconstruction team to solidly promote the orderly construction of disaster areas.

Strengthen the investigation of risks and hidden dangers, and effectively ensure the safety of the lives of the general public.

Establish a disaster learning system and comprehensively improve the ability to analyze the causes of disasters.

3. China Emergency Management

The study also investigates regional emergency management in China through three distinct perspectives: government-based regional emergency management, power grid-specific regional emergency management, and additional forms of regional emergency management.

3.1 Government Regional Emergency Management

The National Regional Emergency Rescue Center serves as a specialized regional command and coordination hub, equipped as a reserve and transportation base. It stands as a crucial strategic asset for the nation, particularly in addressing significant disasters. Primarily, its responsibilities encompass rapid response to nearby calamities, orchestrating specialized rescue operations, marshaling emergency resources, and aiding affected governmental bodies in executing proficient command and coordination. In adherence to the principles of "nearby deployment, rapid mobilization, and systematic rescue" (illustrated in Figure 2), the Emergency Management Department has established six regional centers. The establishment of the National Regional Emergency Rescue Center significantly bolsters regional emergency response, notably within the industrial sectors.

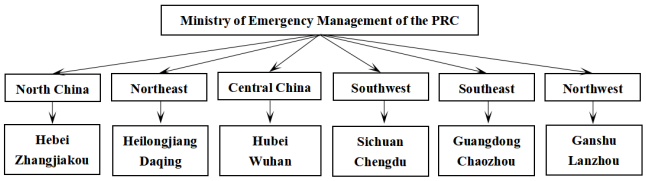

Figure 2 Distribution of national regional emergency rescue centers.

3.2 Power Grid Regional Emergency Management

In recent years, Chinese scholars have extensively researched regional emergency responses within the power grid [5-6], primarily focusing on three main aspects.

1) The management of large-scale power outages stands as a primary focus within the power grid's emergency response efforts. This facet constitutes the most extensive emergency undertaking within the domestic power grid and presently operates at a relatively advanced stage of development. Its core emphasis lies in organizational structure, system design, information exchange protocols, formulation of emergency plans, and assessment strategies specifically tailored

for managing large-scale power outages in the grid.

2) Scholars have conducted research on the specific features of power grid disasters and emergency responses. Power grid accidents are significantly affected by natural calamities such as typhoons, rainstorms, and earthquakes, exerting a substantial impact. As a result, scholarly investigations have primarily focused on three key dimensions: understanding the characteristics of power grid disasters, formulating effective emergency response strategies, and analyzing their implications.

a) To examine the occurrence characteristics (including timing, location, and consequences) of disasters like typhoons and rainstorms, and to assess their impact on the power grid in terms of the extent of damage.

b) To assess the resilience of the power grid's risk from three perspectives: statistical analysis, reliability, and risk management.

c) We will commence our research by identifying critical power lines within the power system, developing backbone network structures, and optimizing the planning and scheduling of disaster prevention measures and emergency power sources. Our focus will be on conducting comprehensive research to devise effective strategies for disaster prevention and emergency optimization within the power system.

3) To enhance the emergency command capabilities of integrated regional power grids, research has focused on cross-regional power grid integration. This research encompasses the development of automatic dispatch systems for cross-regional power grid integration, primarily involving the proposal of methods for emergency command through cross-regional power grid integration.

3.3 Other Disasters Regional Emergency Management

Regional emergency rescue efforts in China predominantly encompass mining rescue, natural disaster response, tunnel collapse rescues, and similar endeavors [7,10-11]. Notably, mining rescue teams have played a pivotal role in these rescue operations. This query utilizes coal mine rescue operations as a case study to illustrate the emergency management dynamics within accident areas.

1) Emergency rescue system

a) Laws and regulations. The Chinese government places significant emphasis on emergency rescue operations within mines. Legal frameworks such as the Mine Safety Law and the Work Safety Law of the People's Republic of China offer substantial legal support for mine rescue initiatives. Additionally, the Coal Mine Safety Regulations underscore the importance of emergency rescue procedures, serving as industry norms within the coal mining sector.

b) Rescue system. The mine emergency rescue system stands as a vital component within the broader national safety production emergency rescue structure. Presently, China focuses on enhancing the national mine emergency rescue system across five key dimensions: rescue management, rescue teams, technical support, equipment support, and communication information systems. This comprehensive approach has facilitated the establishment of a mine emergency rescue system, characterized by government leadership as the primary emergency force at both national (regional), local, and mining enterprise levels.

2) Emergency rescue team

a) Team size. In China's mines, emergency rescue teams primarily comprise two segments: rescue teams and medical teams. Regarding rescue teams, there are 578 full-time mine rescue teams established nationwide, comprising 7 national teams, 14 regional teams, and 19 emergency rescue teams within central enterprises. Additionally, the nation has established a national land search and rescue base. The emergency medical team includes the National Mine Medical Rescue Center, Provincial Mine Medical Rescue Center, and Medical Rescue Stations within mine enterprises.

b) Daily training. The daily training regimen for the ambulance team primarily encompasses physical fitness exercises and skill development. In China, mining rescue teams undergo three main types of physical training: routine training, core strength training, and expansion training. Routine training aligns with the stipulations outlined in the 'Quality Standardization Assessment Specification for Mine Rescue Teams,' focusing on 11 indicators such as pull-up and upward

training. Core strength training targets core muscle groups—shoulders, chest, abdomen, buttocks, and back—following the requisites of competitive sports training. Expansion training extends beyond conventional methods, integrating training into societal or natural settings, combining training with entertainment.

c) Emergency drills. It is primarily categorized into three types: tabletop exercises, practical drills, and virtual simulations.

4. Regional Emergency Management of State Grid Corporation

4.1 State Grid Risk Analysis

Currently, China's power industry employs approximately 2 million workers, who encounter various occupational risks, as detailed in Table 1. In recent years, the occurrence of severe disasters has surpassed the local emergency rescue capacities, emphasizing the critical need to establish a regional emergency management system specifically tailored for the power grid.

Table 1 State grid risk factors.

No	Category	Risk factors
1	Natural disasters	Typhoon, rainstorm, lightning strike, freezing rain and snow, flood, severe convection weather, etc
2	Occupational injury	Electric shock, falling from heights, traffic accidents, object strikes, etc
3	Public safety	Food hygiene, acute infectious diseases, personal safety, fires, etc
4	Receiving-end grid	External electrical shock, AC/DC interaction effects, Insufficient peak shaving capacity of the power grid, etc
5	Dense transmission lines	Fire, widespread power outage, external damage, Wires stolen, etc

Table 2 State grid emergency management execution document.

No	Document publishing department	Amount	Example file
1	National laws	8	1) Work Safety Law of the People's Republic of China 2)Emergency Response Law of the People's Republic of China 3) Law of the People's Republic of China on Electric Power
2	National regulations	10	1) Regulations on Reporting and Investigating Production Safety Accidents 2) Regulations on Emergency Response and Investigation of Electric Power Safety Accidents
3	government department documents	53	1) Management Measures for Emergency Plans for Emergencies 2) National Emergency Plan for Large Area Power Outages 3) National Emergency Plan for Work Safety Accidents and Disasters
4	Standard	14	1) Standard for emergency capability assessment and construction of power grid enterprises 2) Technical specifications for meteorological disaster early warning system of power grid

4.2 State Grid Emergency Management

Different power grids across China prioritize their emergency management efforts, and Table 2 presents the pertinent documents implemented by the State Grid regarding emergency management. These safety management documents play a crucial role in guiding the power grid's emergency management endeavors, offering legal, regulatory, and technical support vital for the regional

emergency infrastructure of the power grid.

4.3 State Grid Emergency Management System

In its administrative structure, State Grid employs a three-level vertical management system consisting of"Power Grid Headquarters, Provincial Companies, and City and County Companies". However, this system overlooks the involvement of regional power grid departments in emergency management, hindering the development of effective regional emergency systems and teams. The establishment of the National Emergency Regional Center warrants a reform in the State Grid's regional emergency construction system.

With the establishment of the regional emergency system within State Grid, the power grid branches will undertake numerous emergency management functions typically managed by headquarters. Consequently, the branches must enhance their safety supervision departments, refine contingency plans, and bolster mechanisms across various facets.

5. Design of Regional Emergency Management for State Grid Corporation

5.1 Design of Regional Emergency Management System

With the development of regional emergency response within the power grid, the power grid branches will take on numerous emergency management functions traditionally held by headquarters. Consequently, this paper asserts that, for effective emergency management, establishing a four-tier management system comprising "power grid headquarters, regional branches, provincial companies, and city and county companies' would be more fitting".

In the power grid division, the Safety Supervision Department oversees safety and emergency operations. Business Department 1, the Security Department, focuses on safety management, primarily aimed at accident prevention. Business Department 2, the Emergency Command Center, handles emergency management, specifically directing daily and emergency rescue operations.

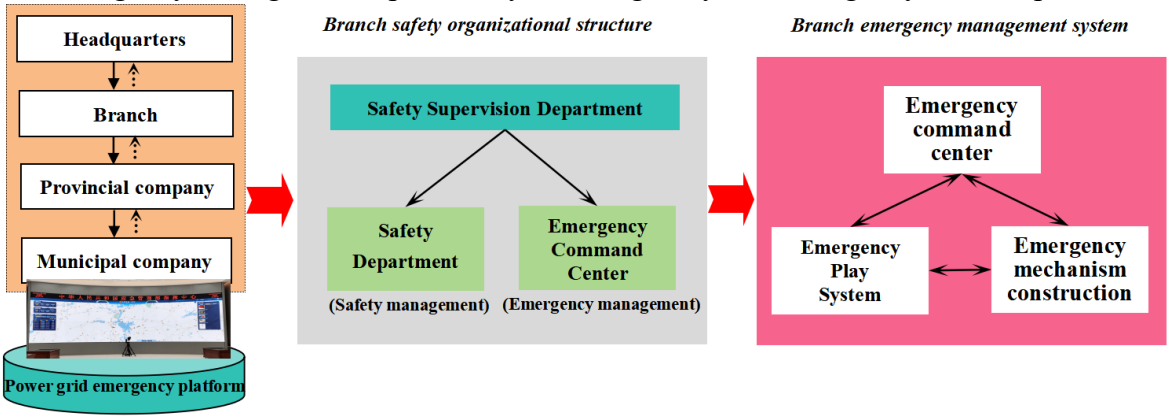

Figure 3 Design of regional emergency management system of state grid corporation of china.

5.2 Emergency Command Center

In the envisioned emergency management system for power grid areas, the emergency command center holds a pivotal role, coordinating and directing emergency operations within the area. Presently, the emergency command centers within each branch face challenges in supporting regional emergency operations, necessitating focused efforts on their enhancement and development.

1) Personnel. The regional emergency command center requires continuous operation, necessitating a 24-hour schedule. Considering the existing staffing levels of safety personnel in the branch, it is evident that the current workforce is inadequate to sustain this operation. Therefore, there is a need to augment the number of personnel to ensure the seamless functioning of the system.

2) Venue. Currently, the regional emergency command center lacks adequate capacity to effectively support regional emergency operations and thus requires an expansion in its physical

infrastructure.

3) Equipment.In order to maintain the regular functioning of the regional emergency command center, both hardware and software equipment are essential. As a result, it's imperative to procure and install the necessary equipment and facilities accordingly.

4) Technology. The integration of regional collaborative emergency command technology stands as a crucial element in ensuring the smooth operation of the command system.

5) Platform. An integrated platform that consolidates and displays information regarding materials, personnel, equipment, and more serves as a cornerstone for enabling effective regional resource allocation. This integrated platform facilitates the sharing of disaster information and extends support for emergency command operations.

5.3 Emergency Play System

The emergency plan system serves as a crucial mechanism in regional emergency management. As the power grid branch assumes numerous emergency management responsibilities previously held by the headquarters, it becomes essential for the branch's emergency plan system to align with that of the headquarters. Table 3 presents an outline of the emergency plan system implemented within a branch.

Table 3 Emergency plan system of state grid east china branch.

No	Category	Emergency plans owned	Comparison with headquarters
1	GeneHc plan	(1) General (comprehensive) emergency plan	Complete
2	Natural disasters	---	None
3	Accidents and disasters	(1) Emergency plan for large-scale power outages (2) Emergency plan for communication system emergencies (3) Emergency plan for scheduling automation system failure	Partial emergency plandeletion
4	Public health	(1) Emergency plan for public health emergencies	Partial emergency plandeletion
5	Social safety	(1) Emergency plan for sudden group incidents (2) Emergency Plan for News Emergencies (3) Emergency plan for sudden terrorist attacks in office buildings (4) Emergency plan for power supply guarantee (5) Emergency Plan for Network and Information System Emergencies (6) Emergency plan for confidentiality and leakage incidents (7) Emergency Plan for Network Security Incidents in Power Monitoring System	Partial emergency plandeletion

The table indicates that, in comparison to the headquarters, the emergency plan system within this branch is deficient. Several contingency plans are absent, particularly in areas concerning accidents and disasters, public health, social safety, and notably, natural disasters where no emergency plan exists. Consequently, there is a need for the branch to align its emergency plan system with that of the headquarters, enhancing the construction of the branch's emergency plan system.

5.4 Emergency Mechanism Construction

The establishment of emergency mechanisms is a crucial assurance for effective regional emergency management. This paper asserts that, considering the necessities of regional emergency operations and leveraging advanced experiences both domestically and internationally in regional emergency management, enhancing specific aspects within the power grid's regional emergency mechanism is imperative.

1) Emergency regulatory protection mechanism. Regulations are fundamental to ensuring the effective execution of emergency management initiatives, and established emergency management systems abroad rely on robust legal frameworks. Consequently, to address regional emergency management needs, State Grid Headquarters ought to introduce regulations and documentation pertaining to regional emergency management. These should distinctly outline the structural framework, operational roles, diverse emergency protocols, and other essential elements. This approach aims to offer precise directives for conducting regional emergency management operations.

2) Emergency rescue team guarantee mechanism

a) Emergency rescue team system. The paper suggests that the power grid's emergency rescue team primarily comprises the power grid accident rescue team (known as the power grid rescue force) and the "national military" rescue support team (an external rescue force). The power grid accident rescue team handles routine emergency rescue operations and receives centralized dispatch from the emergency command center. In instances where an incident surpasses the regional rescue capacity, the emergency command should engage the rescue support team from the emergency management department or the military rescue support team to solicit assistance from external rescue forces.

Drawing on advanced expertise in mining and typhoon rescue operations, this paper advocates prioritizing the enhancement of capacity building for rescue teams.

- Similar to the "Mine Rescue Regulations," the State Grid Corporation of China should formulate the "Power Grid Rescue Regulations" tailored to the distinct characteristics of emergency rescue within the power grid. These regulations would serve as guidelines to direct the rescue operations conducted by power grid rescue teams across all levels.
- Taking cue from the Ministry of Emergency Management's Notice regarding the Standardization and Grading Management Measures for Mine Rescue Teams and the Standardization Assessment Specification for Mine Rescue Teams, State Grid is encouraged to develop the Standardization and Grading Management Measures for Power Grid Rescue Teams and the Standardization Assessment Specification for Power Grid Rescue Teams. These measures will serve to guide the standardization efforts across all levels of power grid rescue teams.
- The State Grid Headquarters has released the "Basic Equipment Standards for Power Grid Rescue Teams" to provide guidance on the equipment setup for power grid regional rescue teams, provincial rescue teams, as well as city and county rescue teams.

b) Daily training of emergency rescue teams

The standardized training outline and assessment standards significantly enhance the rescue capabilities of power grid rescue teams. Taking inspiration from the "Outline and Assessment Specification for Mine Rescue Training," the State Grid Headquarters can release the "Outline and Assessment Specification for Power Grid Rescue Training." This document will serve as a guideline for training and retraining necessities for power grid rescue teams, encompassing training content, class hour arrangements, as well as assessment requirements and methodologies.

Simultaneously, each branch has the opportunity to craft the "Regional Power Grid Rescue Training Outline and Assessment Standards" based on the distinctive features of power grid accidents within its jurisdiction and the specific traits of provincial power grid rescue teams. This document aims to direct the daily training initiatives of power grid rescue teams within its jurisdiction.

c) Emergency drills for emergency rescue teams. The power grid rescue team can mainly conduct three types of emergency drills: desktop drills, practical drills, and virtual drills.

- Desktop exercise. Interactive discussions and deducing emergency decision-making procedures based on hypothetical drill scenarios outlined in the emergency plan aim to familiarize relevant personnel with their responsibilities and procedural requirements specified in the plan. This process significantly enhances command, decision-making, and collaborative capabilities.

- Practical exercises. Engage rescue teams in specific scenarios to carry out hands-on emergency response tasks, allowing team members to complete practical operations. Additionally, practical exercises can align with designated specialized drills, namely, specific training exercises.
- Virtual drill.Utilizing computers and other tools for drills primarily involves two training modes: the contingency plan training mode and the emergency event training mode.

3) Monitoring and early warning guarantee mechanism

The power grid monitoring and early warning system primarily collaborates with meteorological bureaus, earthquake bureaus, and other relevant units to conduct joint emergency research on weather conditions, floods, earthquakes, and other disasters closely impacting the power grid. This collaboration leads to the establishment of a cooperative monitoring and early warning system, illustrated in Figure 4.

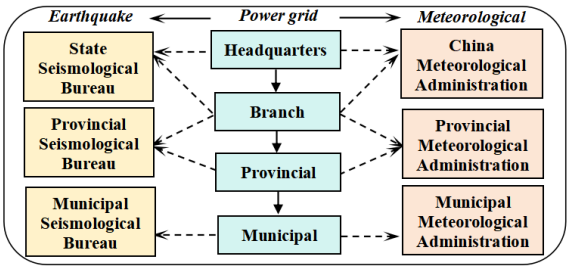

Figure 4 Prediction and early warning guarantee mechanism.

4) Rescue technology support mechanism

To ensure the seamless execution of regional emergency rescue operations, the power grid should institute a rescue technology support mechanism. This mechanism may consist of both an internal technical support system and an external technical support system, illustrated in Figure 5.

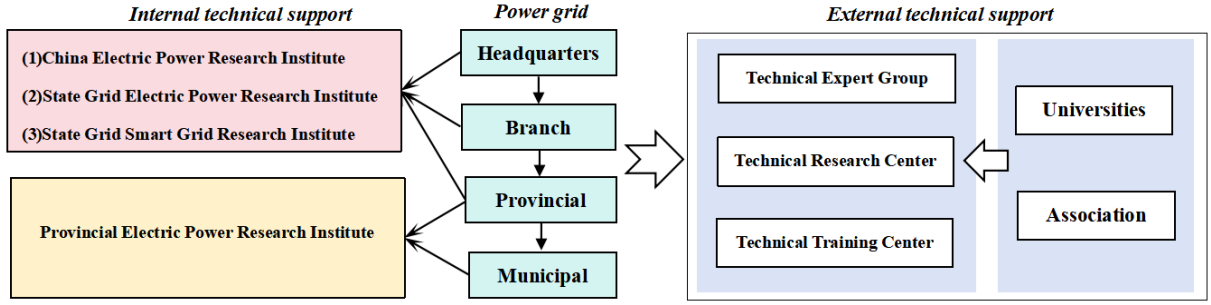

Figure 5 Rescue technology support mechanism

a)The internal technical support system primarily comprises research institutes directly affiliated with the State Grid Corporation of China (such as the China Electric Power Research Institute, State Grid Electric Power Research Institute, and State Grid Intelligent Research Institute), along with provincial power research institutes.

b) The external technical support system may include the power grid rescue technology expert group, power grid rescue technology research center, power grid rescue technology training center, among others. These external technical support systems can involve universities, societies, associations, and similar entities.

5) Risk perception and warning mechanism

The detection and early warning of power grid risks and accidents are pivotal in promptly initiating emergency rescue procedures and mitigating accident-related losses. Hence, it is imperative for the power grid to institute a mechanism for risk perception and early warning. This involves researching the correlation between power grid risks and accidents, delving into the triggering factors and mechanisms that link risks to accidents, thereby furnishing theoretical underpinnings for accident prediction.

6) Accident information sharing mechanism

A robust accident information sharing mechanism across the 4-level emergency management

structure of "State Grid Headquarters - Regional Branches - Provincial Companies - City and County Companies" significantly aids in power grid emergency rescue operations. Figure 6 illustrates the possibility of establishing an emergency platform within the power grid to facilitate the creation of an accident information sharing mechanism in case of emergencies.

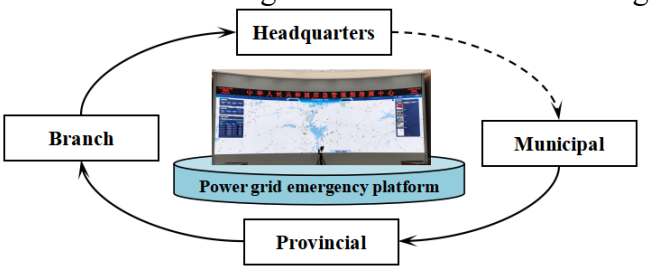

Figure 6 Accident information sharing mechanism

7) Emergency communication guarantee mechanism

Establishing an emergency communication mechanism at the accident site stands as a crucial cornerstone for achieving accident information sharing. With the evolution of integrated information technology, as depicted in Figure 7, facilitating emergency communication for power grid accidents will progressively become more convenient.

Figure 7 Emergency communication guarantee mechanism.

During a power grid accident, on-site information can be obtained through photography. In situations where access to the site is restricted, drones can perform aerial photography of the accident area. This gathered information is relayed to the satellite communication vehicle and transmitted via communication satellites to reach the power grid emergency platform. Consequently, information sharing will be established among the four levels of emergency management departments: State Grid Headquarters-Regional Branches-Provincial Companies-City and County Companies.

6. Conclusion

To enhance the regional emergency management of the power grid, this paper undertakes the design and analysis of China's power grid regional emergency management system, drawing insights from both domestic and international emergency management practices. The primary conclusions derived from this study are outlined below.

(1) Implementing regional emergency management for the power grid aligns with a prevailing trend both within domestic and international contexts. This approach is in harmony with China's comprehensive emergency management strategy and the current requirements of China's power grid emergency management efforts.

(2) The regional emergency response within the power grid ought to revolve around the emergency command center as the focal point, initiated by the contingency plan system, and fortified by mechanism construction as the guarantee. Establishing a four-level management system encompassing "power grid headquarters, regional branches, provincial companies, and city and county companies" is paramount.

(3) The regional emergency command center should focus on strengthening personnel, venues, equipment, technology, platforms, and other aspects. The branch contingency plan system should

correspond to the headquarters and need to be supplemented and improved in areas such as natural resources.

(4) From the perspective of addressing regional emergency requirements, it is crucial to enhance seven pivotal assurance mechanisms. These encompass emergency regulations, emergency rescue teams, monitoring and early warning systems, rescue technology, risk perception and early warning systems, accident information sharing protocols, and emergency communication systems.

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