

# Research and Implementation of Optimization and Promotion of Power Grid Emergency Command Center

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**Abstract.** In order to enable the power grid emergency command center to meet the needs of the emergency work under the current new situation, and provide strong support for emergency response and important activities of power conservation, based on the in-depth study and analysis of the application scenarios and basic business of the power grid emergency command center, combined with advanced information communication technology, and studied the optimization and upgrading methods of the power grid emergency command center. Through the research on the optimization and upgrading method of power grid emergency command center, the optimization and upgrading scheme is proposed to guide the power grid enterprises to carry out the optimization and upgrading work of emergency command center. The optimization and upgrading scheme of the power grid emergency command center will be used for the transformation and upgrading of the emergency command center of the power grid companies at all levels, which will help the power grid companies at all levels to improve their emergency.

## 1. Introduction

As a public infrastructure for the national economy and people's livelihood, power grid bears the important responsibility of providing reliable power supply for the society, so that the safe and stable operation can directly affect social stability and people's production and life. In recent years, a variety of natural disasters have occurred frequently and shown an increasing trend in China. Typhoons, heavy rainfall, geological earthquake, freezing rain and snow disasters have brought huge losses to the power grid, and seriously affected the safe and stable operation of power grid and the normal production and operation of power grid companies. In addition, man-made accidents such as terrorist attacks can exert a bad impact on the security of the power grid. In this context, the power grid companies at all levels have established emergency command centers to deal with various emergencies and carry out rapid and efficient rescue and disaster relief [1-2].

Since their establishment, the existing emergency command centers have initially met the needs of daily emergency management and emergency response. With the higher requirements of the state for the construction of emergency capacity, the continuous optimization of the emergency system of the power industry, the continuous development of emergency business, the introduction of information technology, the continuous improvement of the emergency management and emergency response capacity of the power industry, the emergency work of

power grid companies are facing several new situations. The situations are mainly manifested in:

### 1.1 Frequent occurrence of natural disasters challenges emergency management

With the rapid development of China's economy, the power grid construction continues to accelerate. China's existing power grid is large in scale and complex in structure. In addition, natural disasters such as typhoons, rain and snow freezing, floods and geological earthquakes occur frequently. Extreme disasters will cause major damage to power facilities, pose a serious threat to the safe operation of the power grid, and may even cause cascading failures to result in large-scale blackouts [3-6]. Whether electric power, as a basic industry related to the national economy and the people's livelihood, can be restored quickly has attracted widespread attention from the society. In addition, the efficient disposal of accident disasters, public health and social security incidents should also be highly valued [7].

### 1.2 Power conservation of important activities puts forward higher requirements for emergency command center

With the continuous development of China's economy and the major strategy of the "the Belt and Road", China's international status and influence are increasingly strengthened, so that there are more and more international political, cultural, sports and economic activities with great influence and significance held in

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China, leading to the higher requirements for power grids, especially those in key regions, to ensure power supply services [8]. Power supply guarantee is an important part of activity guarantee, with high requirements and arduous tasks. As the core place for power supply guarantee, emergency command center should have the functions of overall view, information fusion, efficient intelligence, and aided decision-making.

### 1.3 Advanced technology provides more tools for emergency command

With the continuous development of the current social information technology, the advanced information and communication tools, represented by cloud computing, big data, the Internet of Things, mobile Internet, and artificial intelligence, can provide more support for the optimization and promotion of the power grid emergency command capability, enabling the previously impossible emergency command concept to be realized, the previously impossible emergency command concept to be implemented, and the previously impossible emergency command work to be completed [9-13].

As the focus of the current emergency management is gradually changing from the post-accident emergency disposal to the pre-accident emergency preparation, the existing emergency command center can no longer meet the needs of the emergency work under the current new situation in terms of function and application mode. Therefore, it is urgent to carry out the optimization and promotion of the emergency command center, so that the emergency command center can provide strong support for the emergency disposal and the power conservation of important activities.

The advanced concepts of the accident emergency command system, Internet Connection Sharing (ICS), and the goal-oriented formulation of functional requirements can improve the capability and efficiency of the emergency command center to respond to major emergencies. According to a great deal of practice, the effectiveness of the ICS system mainly depends on whether the participants have known about the system before application [14]. Therefore, the promotion method should enhance the interpretability of the system as much as possible, and accelerate the understanding of participants in the system. In order to improve the sense of field command, the scenario construction technology is used to integrate the actual emergency command scene and basic service.

In this paper, the emergency command center is analyzed from the perspectives of application scenarios and basic services, and finally an optimization and upgrading scheme is proposed for the emergency command center.

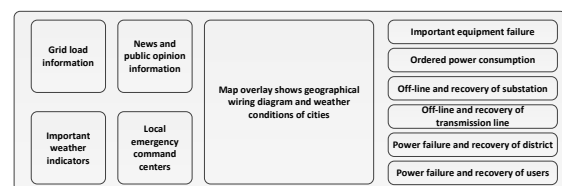
## 2. Application Scenario Analysis

Scenario construction is the basis for improving the decision-making capability of the emergency command center [15]. The power grid emergency command center is the place where the power grid companies at all levels carry out emergency duty and command meetings.

Meanwhile, it should also be used as a multimedia conference room in video conference and training [16]. In order to meet the needs of emergency work under the new situation, provide comprehensive support for the emergency work of power grid enterprises, and make full use of the emergency command center in line with the principle of "combining peacetime and war", the emergency command center should work in a variety of scenarios with different priorities. This paper summarizes the application scenarios of the emergency command center into the following six categories:

### 2.1 Application Scenario of Duty in Summer

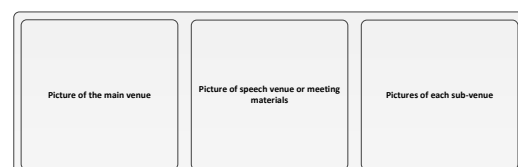
In order to highlight social responsibility and improve service quality, the power grid companies at all levels have attached great importance to the smooth and orderly power supply during the national electricity peak every summer in recent years, and have arranged the duty in summer, which has gradually become a major application scene of the emergency command center. This scenario is featured by that during the duty in summer, when there is no major emergency, the personnel on duty will keep an eye on the operation of the power grid, the power consumption of customers and the weather conditions that are easy to affect the power grid, so as to ensure the safe and stable operation of the power grid and be ready to deal with major emergencies at any time. Its application scenario is shown in Fig. 1.



**Figure 1.** Application scenario of duty in summer.

### 2.2 Application Scenario of Video Conference

In order to save time and economic costs, more and more meetings have been held by video in recent years. The emergency command center is the main place for video conference in the emergency field. When holding the video conference of the power grid headquarters, the subordinate provincial companies, and the subordinate municipal companies, it is necessary to ensure that the conference is conducted in an orderly manner. The main venue can timely grasp the situation of each sub-venue and push the conference materials (if any) to each sub-venue in real time. Its application scenario is shown in Fig. 2.



**Figure 2.** Application scenario of video conference.

### 2.3 Application Scenario of Emergency Disposal

Emergency disposal and aided emergency command are the most basic and core requirements of the emergency command center. The emergency disposal is also the most important application scenario of the emergency command center. This scenario is featured by that during the emergency disposal process, the basic information of the emergency, the damage and recovery of the power grid, the input of emergency resources, the emergency plan, the situation of the emergency scene are collected into the emergency command center for the analysis and prediction of the impact of the event, the prediction of the emergency resource demands and the formulation of the emergency response reference plan. Its application scenario is shown in Fig. 3.

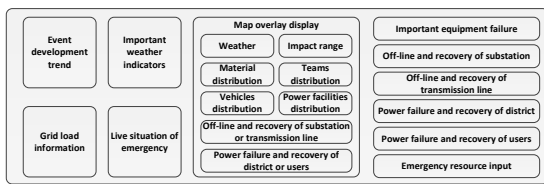


Figure 3. Application scenario of emergency disposal.

### 2.4 Application Scenario of Power Protection for Important Activities

Due to the important position of the emergency command center as the core place of power supply guarantee for important activities, the power supply guarantee for important activities has become another main application scenario of the emergency command center. This scenario is applied to the power supply guarantee for major political and economic conferences and other important activities at home and abroad. This scenario is featured by continuous attention to the operation of the power grid, the key protection of power supply for users and the weather conditions that are easy to affect the power grid during important activities, to ensure the safe and stable operation of the power grid, the key protection of stable power supply for users, so as to respond to major emergencies. Its application scenario is shown in Fig. 4.

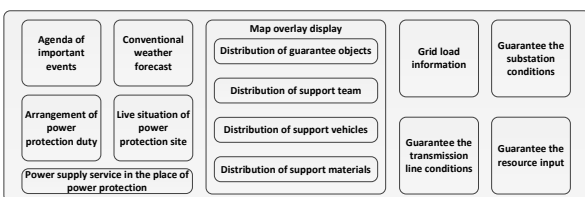


Figure 4. Application scenario of power protection for important activities.

### 2.5 Application Scenario of Emergency Drill

As an effective working method to check the emergency plan and train the team, emergency drill has become one of the important tasks that each company must carry out every year. The emergency command center is one of the main places for emergency drills. The emergency drill scenario is characterized by serving various emergency drills. During the emergency drill, it can fully display the

relevant information of the drill, highlight the drill focus, and clarify the drill process, in order to provide support for the smooth implementation of the emergency drill. Its application scenario is shown in Fig. 5.

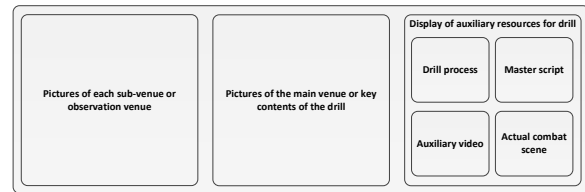


Figure 5. Application scenario of emergency drill

### 2.6 Application Scenario of Visit and Display

The emergency command center is the gathering place of all emergency information. After the construction of the emergency command center, it can be used as the best platform to display the results of the emergency work during the inspection of the superior unit or the visit of the associate organizations. This scenario is featured by the need to fully display the company's emergency work results and the highlights of the work. Its application scenario is shown in Fig. 6.

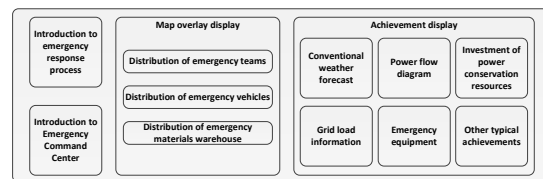


Figure 6. Application scenario of visit and display.

## 3. Basic Business Analysis

According to the commonness of scenarios, the basic functional requirements are obtained to serve the power grid emergency system, meet the business requirements of different application scenarios, and further provide the basic business optimization and upgrading scheme for the organic combination of basic services and new information technology. After the upgrading of the emergency command center, 14 basic businesses including monitoring and early-warning, emergency management, event impact prediction, statistical analysis, Audio-visual (AV) resource integration, mobile emergency command, intelligent plan management, grass-roots staff team management, emergency supplies management, emergency vehicle management, aided intelligent decision-making, large-screen visualization, internal data access, and external data access, should be realized. See Fig. 7 for the business architecture of the emergency command center.

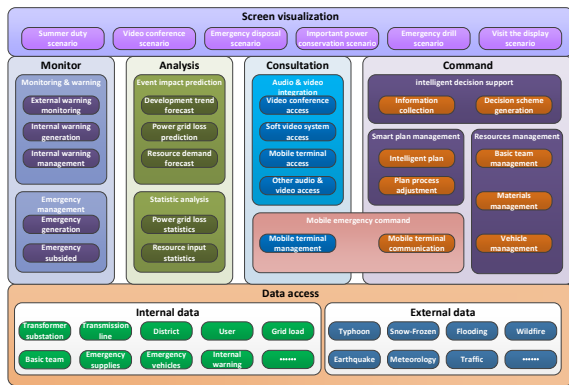


Figure 7. Business architecture.

### 3.1 Monitoring and Early-warning

It is necessary to analyze the monitored external early-warning information or the operation early-warning information of power equipment and facilities, predict its possible impact on the power grid and the scope of impact, and generate and release internal early-warning information if necessary. This is mainly to realize the functions of external early-warning information monitoring, internal early-warning information generation, and internal early-warning information management.

### 3.2 Emergency Management

When an emergency occurs or the power protection of an important activity begins, it is necessary to clarify the relevant event, and conduct the subsequent disposal work around the event. This is mainly to realize the functions of generating and calming emergencies.

### 3.3 Event Impact Prediction

The accessed internal and external data are applied to predict the event impact degree, scope and emergency resource demand in advance. Moreover, the prediction results can be used for emergency command and decision-making reference. This is mainly to realize the functions of event development trend prediction, power grid loss prediction and emergency resource demand prediction.

### 3.4 Statistical Analysis

The report tools are used to summarize and count the data of power grid damage and recovery, power outage and recovery of stations and users, and emergency resource input reported by various places, so as to provide a basis for emergency command and decision-making. This is mainly to realize the statistics of power grid damage and recovery, and emergency resource input.

### 3.5 AV Resource Integration

It is necessary to integrate the audio and video information of the emergency command center's AV equipment, video conference system, soft video system, mobile emergency terminal, transformer substation video, fixed telephone and other on-site monitoring equipment. Through video conference access, soft video system

access, intelligent mobile terminal access, and other AV equipment access, relevant personnel can participate in the AV conference in different ways at different places. Meanwhile, the participants can grasp the scene dynamics in a timely manner.

### 3.6 Mobile Emergency Command

Intelligent mobile terminal, satellite communication system and ground wireless network are used to build mobile emergency command service application connecting intelligent mobile terminal and emergency command center on site. This is mainly to realize the collection of on-site information, the information interaction between the site and the emergency command center, and the positioning and navigation based on intelligent terminals.

### 3.7 Intelligent Plan Management

It is necessary to manage all emergency response plans. Furthermore, emergency plans should be intelligent, streamlined and visualized to realize plan intelligence and process adjustment, thus providing the basis for emergency command and decision-making.

### 3.8 Grass-roots Staff Team Management

Relying on intelligent mobile terminals and intelligent wearable devices, the mobile emergency command subsystem is utilized to strengthen the command and management of the emergency grass-roots team members in emergencies or power protection sites. This is mainly to realize the functions of grass-roots staff team's location query, command issuance and urgent call.

### 3.9 Emergency Vehicle Management

The accessed emergency vehicle status and location data can be used to grasp the situation of emergency vehicles in a timely manner and realize the unified deployment and management of emergency vehicles. This is mainly to realize the functions of emergency vehicle status query, location query and allocation.

### 3.10 Emergency Supplies Management

Based on the accessed emergency supplies data, emergency supplies inventory can be timely grasped for carrying out the unified allocation. Relying on intelligent mobile terminals or emergency vehicles, the location information of emergency materials can be obtained to provide the basis for emergency command and decision-making. This is mainly to realize the functions of emergency supplies inventory query, allocation and location query.

### 3.11 Aided Intelligent Decision-making

It is necessary to summarize emergency-related information, accurately select key information from complicated internal and external information, identify the affected power grid situation and event development trend, and then automatically generate emergency disposal plan for decision-makers' reference according to

the preset emergency disposal process and current event-related information. This is mainly to realize the functions of collecting information related to emergencies and generating aided decision-making schemes.

### **3.12 Large-screen Visualization**

Rich visual display technologies are used to set up display modes for different application scenarios of the emergency command center for large-screen visual display. This is mainly to realize the function of providing users with different display resources for large-screen visual display according to different concerns in different application scenarios.

### **3.13 Internal Data Access**

It is necessary to integrate the data of power grid dispatching, power grid equipment and facilities, power users and emergency supplies (equipment), so that the power grid operation status data, early-warning data, basic power user data, power consumption data, emergency plan data, emergency team data, emergency supplies data, emergency vehicle data, the power grid loss data affected by emergencies, and emergency resource input data can be accessed.

### **3.14 External Data Access**

The information of disasters, including mountain fire, typhoons, flood, freezing weather and earthquake, as well as traffic conditions, can be accessed and integrated for the application.

## **4. Upgrading Scheme of Emergency Command Center**

### **4.1 Upgrading Target**

The target is to improve the functions of the emergency command center, integrate various kinds of disaster monitoring and early-warning information, improve the real-time and visualization level of emergency information, introduce advanced technology and equipment, and build an emergency platform with integrated application of "monitoring, analysis, consultation, and command".

#### **4.1.1 *Build the emergency business cloud to realize the centralized application of emergency data.***

It is necessary to make full use of the Internet of Things construction achievements of each company to complete the access of internal and external data, such as the basic data of power equipment and facilities, the loss data of power equipment and facilities, the emergency resource data, the monitoring and early-warning data of natural disasters, and realize the real-time access to emergency information. On this basis, the emergency business cloud is built to provide data support for emergency business applications.

#### **4.1.2 *Build the monitoring and early-warning application to realize the timely and accurate release of early-warning information.***

After monitoring the early-warning of the operation of new power equipment and facilities or various natural disasters, relying on the emergency business cloud and using advanced information technologies such as big data analysis, artificial intelligence, the impact scope and extent of the event can be analyzed. Different types and levels of warning information should be issued to relevant companies in a timely manner according to the different degrees of expected impact.

#### **4.1.3 *Build the impact prediction application to realize the beforehand prediction of the impact of emergencies on the power grid.***

According to the current development of natural disasters and other emergencies, relying on the emergency business cloud, using advanced information technologies such as big data analysis and artificial intelligence, the impact degree, scope and emergency resource demand of the event can be predicted in advance. The prediction results can be used as reference for emergency command and decision-making.

#### **4.1.4 *Build the mobile emergency command application of the space-earth integration network to realize zero distance between the emergency command center and the site.***

According to the introduction of advanced intelligent mobile terminals and intelligent wearable devices, based on mobile Internet and satellite communication technology, a communication channel between the emergency command center and the power protection site of emergencies or important activities can be built.

#### **4.1.5 *Build the emergency command AV consultation re-source pool to achieve the barrier-free emergency disposal consultation.***

Various AV communication tools and advanced information technologies can be used to build the AV conference resource pool for emergency command, so that relevant personnel can participate in the AV conference anytime and anywhere.

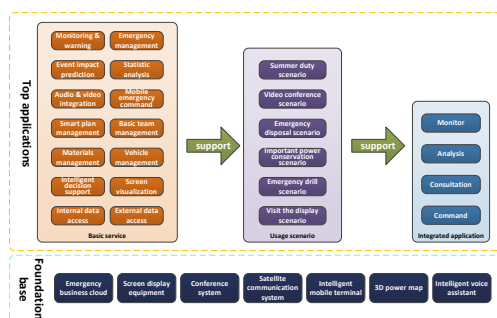
#### **4.1.6 *Build the visual emergency command application to realize the visualization of emergency command and aided decision-making.***

3D power map should be drawn to realize more intuitive simulation of power facilities and geographical environment. Intelligent voice assistant should be built to obtain information quickly and conveniently. An intelligent plan module should be built to make

emergency plans in a smart, streamlined and visible way. An emergency resource management module should be built to grasp the distribution of emergency supplies, emergency teams and emergency vehicles in real time. An automatic statistics module should be built to collect and count the data of power grid affected by emergencies reported by various regions. An aided intelligent decision-making module should be built to put forward the emergency disposal plan reference for aided decision-making. The flexible visualization technologies should be applied to display all kinds of emergency information in real-time, panoramic and whole-process visualization, so as to realize the visualization of emergency command and aided decision-making.

## 4.2 Overall Architecture

Based on the emergency business cloud, the emergency command center can complete the access and fusion application of publicly released information of natural disasters, such as typhoons, icing and flood, with the internal information of the power grid. The monitoring and early-warning application and the impact prediction application can be used to complete the emergency monitoring, early-warning and impact analysis and prediction. Supported by large screen, conference system, satellite communication system, and intelligent mobile terminal, the real-time communication between the emergency command center and the site, as well as the emergency command and aided intelligent decision-making, can be completed by using the emergency command application of space-earth integration network and the emergency command AV conference resource pool. Based on the visual emergency command application, the real-time, panoramic and whole-process visual display of various information of power protection for emergencies or important activities can be completed, so that the integrated application of “monitoring, analysis, consultation and command” can be finally realized, as shown in Fig. 8.



**Figure 8.** Overall architecture.

## 4.3 Upgrading Content

### 4.3.1 Monitoring and Early-warning.

It is necessary to analyze the monitored external early-warning information or the operation early-warning information of power equipment and facilities, predict its possible impact on the power grid and the scope of impact,

and generate and release internal early-warning information if necessary. This is mainly to realize the functions of external early-warning information monitoring, internal early-warning information generation, and internal early-warning information management.

### 4.3.2 Event Management.

When an emergency occurs or the power protection of an important activity begins, it is necessary to clarify the relevant event, and conduct the subsequent disposal work around the event. This is mainly to realize the functions of generating and calming emergencies.

### 4.3.3 Event Impact Prediction.

The accessed internal and external data are applied to predict the event impact degree, scope and emergency resource demand in advance. Moreover, the prediction results can be used for emergency command and decision-making reference. This is mainly to realize the functions of event development trend prediction, power grid loss prediction and emergency resource demand prediction.

### 4.3.4 Statistical Analysis.

The report tools are used to summarize and count the data of power grid damage and recovery, power outage and recovery of stations and users, and emergency resource input reported by various places, so as to provide a basis for emergency command and decision-making. This is mainly to realize the statistics and reporting of power grid damage and recovery, and emergency re-source input.

### 4.3.5 AV Resource Integration.

It is necessary to integrate the audio and video information of the emergency command center’s AV equipment, video conference system, soft video system, mobile emergency terminal, transformer substation video, fixed telephone and other on-site monitoring equipment. Through video conference access, soft video system access, intelligent mobile terminal access, and other AV equipment access, relevant personnel can participate in the AV conference in different ways at different places. Meanwhile, the participants can grasp the scene dynamics in a timely manner.

### 4.3.6 Mobile Emergency Command.

Intelligent mobile terminal, satellite communication system and ground wireless network are used to build mobile emergency command service application connecting intelligent mobile terminal and emergency command center on site. This is mainly to realize the collection of on-site information, the information interaction between the site and the emergency command center, and the positioning and navigation based on intelligent terminals.

#### 4.3.7 *Intelligent Plan Management.*

It is necessary to manage all emergency response plans. Furthermore, emergency plans should be intelligent, streamlined and visualized to realize plan intelligence and process adjustment, thus providing the basis for emergency command and decision-making.

#### 4.3.8 *Emergency Resource Management.*

The management of emergency resources of each company mainly includes:

Emergency expert management. It should realize the management of emergency experts, mainly including the management of basic information of expert units, professions, specialties and experience. Moreover, the functions of appointment, renewal and dismissal of emergency experts should be provided.

Emergency team management. Relying on intelligent mobile terminals and intelligent wearable devices, the mobile emergency command subsystem is utilized to strengthen the command and management of the emergency team members in emergencies or power protection sites. This is mainly to realize the functions of emergency team's location query, command issuance and urgent call.

Emergency vehicle management. The accessed emergency vehicle status and location data can be used to grasp the situation of emergency vehicles in a timely manner and realize the unified deployment and management of emergency vehicles. This is mainly to realize the functions of emergency vehicle status query, location query and allocation.

Emergency supplies management. Based on the accessed emergency supplies data, emergency supplies inventory can be timely grasped for carrying out the unified allocation. Relying on intelligent mobile terminals or emergency vehicles, the location information of emergency materials can be obtained to provide the basis for emergency command and decision-making. This is mainly to realize the functions of emergency supplies inventory query, allocation and location query.

#### 4.3.9 *Aided Intelligent Decision-making.*

When an emergency occurs, the release and feedback of important on-site information and emergency repair tasks should be analyzed continuously, so that the decision-making reference can be provided to emergency commanders, mainly including:

Decision scheme generation. It is necessary to summarize emergency-related information, accurately select key information from complicated internal and external information, identify the affected power grid situation and event development trend, and then automatically generate emergency disposal plan for decision-makers' reference according to the preset emergency disposal process and current event-related information.

Emergency repair tasks management. The management of emergency repair tasks in the event of an emergency mainly includes the functions of emergency repair task

generation, distribution and feedback, which can provide support for the next decision of the emergency commanders.

#### 4.3.10 *Large-screen Visualization.*

Rich visual display technologies, such as 3D maps, customized charts, and traditional tables, should be used to set up display modes for different application scenarios of the emergency command center for large-screen visual display. This is mainly to realize the function of providing users with different display resources for large-screen visual display according to different concerns in different application scenarios.

#### 4.3.11 *Data Integration*

The internal data, such as power grid dispatching, power grid equipment and facilities, power users and emergency supplies (equipment), and the external data, such as meteorology and geology, should be integrated to realize the collection, integration and storage of multi-source internal and external power emergency data.

## 5. Conclusion

First of all, the new situation faced by the power grid emergency command center is elaborated in this paper. Secondly, Combined with the current new situation, an in-depth analysis is made on the emergency command center from two aspects of application scenarios and basic business, so as to summarize six application scenarios of the emergency command center, including duty in summer, video conference, emergency disposal, power protection for important activities, emergency drill, and visit and display, as well as 14 basic businesses, including monitoring and early-warning, emergency management, event impact prediction, statistical analysis, AV resource integration, mobile emergency command, intelligent plan management, grass-roots staff team management, emergency supplies management, emergency vehicle management, aided intelligent decision-making, large-screen visualization, internal data access and external data access. Finally, on the basis of satisfying the needs of the six application scenarios and 14 basic businesses, combined with the advanced information technologies, the optimization and upgrading scheme of the emergency command center is proposed. The effective optimization and promotion of the emergency command center will greatly improve the emergency command efficiency of the power grid companies at all levels, and play a huge role in the emergency disposal of power grid emergencies.

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