The application of an integrated monitoring system for power distribution and consumption

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Abstract. In view of the fact that the traditional integrated power distribution and consumption monitoring system and power information acquisition system are independent of each other, and the data between the two systems are not shared and reused, which brings great obstacles to the construction of new power systems, this paper proposes an integrated power distribution and consumption monitoring system. The system can simultaneously collect distribution monitoring data and power consumption information data, and accurately perceive the panoramic data of power systems such as high voltage power line, distribution transformer area, low voltage power line, metering tank and so on. Through big data statistical analysis and accurate prediction of fault events, realize the two-way interaction between distribution side and power consumption side, reduce power maintenance costs, improve power supply quality, it provides a strong guarantee for the safe operation of power distribution and electrical equipment.

1. Introduction
With the large scale upgrading of China's power system and the upgrading of distribution monitoring equipment in large industrial and mining enterprises, industrial and mining enterprises have higher and higher requirements for intelligent power distribution and consumption integrated system [1-2]. The system can comprehensively monitor the operation status of the whole power grid, monitor the operation status of primary and secondary side equipment, realize the four functions of telemetry, remote signaling, remote viewing and remote control, and query the historical power consumption records, report display, accident analysis, etc. The existing system mainly focuses on the monitoring of medium voltage and high voltage distribution, and lacks the monitoring and control of low voltage power consumption [3-4]. For some power consumption information acquisition systems, they only realize the power consumption data acquisition and control of ordinary residents and special transformer users, but fail to realize the collection and control of distribution data. In short, there is a separation between power consumption and distribution data, and fail to realize the integration of distribution and power consumption business [5-6].

Distribution monitoring equipment is an important infrastructure in the power system. It is generally used for voltage reduction to deliver high voltage to thousands of households after voltage reduction. The safe operation and normal detection of distribution room plays an important role in power system construction [7]. However, due to the scattered deployment positions of the distribution room, it is generally sealed, and the detection equipment in some distribution rooms is old and needs to be read manually, resulting in great difficulties in the monitoring and troubleshooting of the distribution room [8].
Compared with the traditional system, the integrated monitoring system of distribution and power consumption proposed in this paper realizes the data sharing of distribution and power consumption business, improves the data integrity rate by 6.5%, saves 2 hours of operation and maintenance time, and improves the data security rate by 80%. Table 1 describes the comparison of performance indexes between the existing system and the system in detail. From the comparison of data reuse rate of distribution and power consumption, data acquisition integrity rate, operation and maintenance efficiency, data security and other aspects, it shows that the system has greater performance advantages than the existing system.

| Serial number | Performance index item                  | Existing system | This system  | Promotion rate |
|---------------|----------------------------------------|----------------|-------------|---------------|
| 1             | Data reuse rate                        | /              | 100%        | 100%          |
| 2             | Data integrity                         | 92%            | 98%         | 6.5%          |
| 3             | Operation and maintenance time         | ≥ 4 hours      | ≤ 2 hours   | 100%          |
| 4             | Data security rate                     | 50%            | 90%         | 80%           |

2. System physical architecture
The integrated power distribution and consumption monitoring system adopts a layered architecture design to establish a multi-level and loosely coupled enterprise level monitoring and management platform. Figure 1 describes the physical architecture of the system, including system layer, network layer, acquisition layer, monitoring layer, etc. The system layer is mainly composed of servers, printers and other equipment, the network layer is mainly composed of switches and routers, the acquisition layer is composed of concentrators, and the monitoring layer is mainly composed of three-phase smart meters, three-phase three wire multi-function meters, three-phase four wire multi-function meters, cameras, temperature control devices, water immersion sensors, temperature and humidity sensors, etc. The concentrator and communication manager are acquisition equipment, which are responsible for collecting power consumption data of electric energy meter, multi-function meter, air conditioner, temperature and humidity sensor, camera and other equipment signals, and uploading the collected basic data to the front-end computer of the main station through optical fiber, Ethernet and 4G network.
3. System business architecture
The integrated power distribution and consumption monitoring system can comprehensively monitor the operation of the whole power grid and the status of primary equipment in the substation. Figure 2 describes the telemetry, remote signaling, remote control, historical records, reports, accident analysis, etc. of the distribution system; At the same time, collect the energy consumption data of customers, including metering data and event records, so as to realize the power consumption information collection function.

The equipment monitored by the power distribution integrated monitoring system mainly includes: incoming switch cabinet, outgoing switch cabinet, compensation capacitor, DC power supply system and fire protection system. The main business function of the integrated power distribution and consumption monitoring system is to carry out real-time monitoring and remote monitoring of the above equipment.
3.1. Telemetry function
The integrated power distribution monitoring system provides a unified data acquisition platform, which can access all kinds of communication management machines, high voltage multi-functional network instruments, low voltage multi-functional network instruments and environmental monitoring sensors, mainly including temperature and humidity sensors, water immersion sensors and network cameras, so as to realize the unified access of power distribution monitoring data.

The distribution monitoring center is responsible for monitoring the operation status of the whole distribution system and the environmental status of the distribution room, so as to realize the real-time monitoring of parameters such as voltage, current, power, power factor, frequency, harmonic, phase angle, electric quantity and so on. At the same time, the real-time monitoring of all electric parameters, temperature, humidity and water level information at the low voltage side shall be carried out. Any abnormal problems found shall be reported to the monitoring center in time, and the monitoring center shall push the alarm information to the customer's mobile operation terminal in time to inform the customer to deal with the abnormal problems.

3.2. Statistical analysis
The system supports statistical analysis. According to the needs of operation, the system shall be able to carry out statistical analysis on different electric energy operation data, load data, equipment data and other data in the region, have flexible customized calculation formulas, provide statistical results, and display the results of statistical analysis in different forms, such as reports and graphics, which is the main statistical analysis function.

(1) Numerical statistics: including maximum value, minimum value, peak to peak value, average value, total added value and three-phase unbalance rate. The statistical period includes year, quarter, month, week, day, hour, etc.

(2) Extreme value statistics: including maximum value and minimum value. The statistical period includes year, quarter, month, week, day, hour, etc.

(3) Contemporaneous comparison: it can analyze and compare the same type of data collected in different periods.

3.3. Real time monitoring
The system automatically monitors the operation conditions and equipment status of the integrated monitoring system for power distribution and consumption. The monitoring scope covers the real-time operation status of high voltage distribution equipment, power distribution monitoring equipment and

Figure 2. Business architecture of integrated power distribution and consumption monitoring system

Functions of power distribution and consumption integrated monitoring system
- Telemetry function
  - voltage
  - current
  - power
  - frequency
  - Demand
  - energy
  - harmonic
  - ...
- Monitoring display
  - Configuration display
  - Power consumption analysis
  - Abnormal alarm
  - Energy use display
  - Line loss analysis
- Statistical report
  - Electricity Report
  - Load Report
  - Peak valley Report
- Environmental monitoring
  - Temperature monitoring
  - Humidity monitoring
  - Water immersion monitoring
- Power consumption data
  - Measurement data
  - Event record

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other equipment, mainly including the voltage, current, frequency, temperature, active and reactive power, phase, power factor, system fault signal, equipment operation alarm signal, voltage fluctuation, harmonic power quality signal, etc.

The distribution management center is the data analysis and processing center of the distribution system, which realizes the analysis functions of enterprise users, such as power analysis, load analysis, power consumption composition analysis, branch power out of limit analysis, time-sharing power analysis, branch power comparison analysis, statistical analysis of different line failure rates, statistical analysis of fault types, etc. The purpose of power distribution management center is to help enterprises use electricity economically, safely and provide reliable power distribution management center.

3.4. Power distribution monitoring display

The data display center is the core business of the intelligent power distribution and consumption integrated monitoring system. It is mainly divided into energy consumption data display and distribution monitoring display. The energy consumption data display mainly includes the analysis of the overall energy consumption data of the enterprise, which is displayed in the form of energy consumption curve, histogram, report, etc. Distribution monitoring display includes distribution wiring diagram display, monitoring point operation status display, alarm information display, monitoring equipment file display, statistical report display, etc., which is convenient for customers to view the energy consumption and equipment operation of the whole distribution system.

The system displays various collected power data, equipment operation status information, alarm information and equipment files in reports, curves, histograms and configuration diagrams. The display interface can be configured according to customer needs. The operation of the whole distribution network can be checked locally or remotely, so as to find the fault of lines or equipment and eliminate the fault in time.

4. Experimental verification

An integrated power distribution and consumption monitoring system meets the needs of new power systems construction. The system can effectively support the development of new businesses such as low voltage power distribution operation state perception, power consumption data, distribution data monitoring and control, new energy access management, orderly power consumption management and so on. Through system deployment and pilot construction, the system is applicable to the needs of distribution business and power consumption business, meets the monitoring and control of new energy access of new power systems, and improves the security and stability of power distribution monitoring network. Figure 4 shows the daily load curve and monthly power consumption of the system statistics, and the data sharing is realized.

According to the national, industrial and enterprise standards and specifications, the scheme carries out system function and performance verification test by building a simulated operation environment to meet the national, industrial and enterprise system construction standards and specifications. Through systematic stress test, performance test and function test, the performance index of the system meets the expected goal.

![Daily load curve and monthly power consumption data sharing display diagram](image)
5. Conclusion
The application of an integrated power distribution and consumption monitoring system proposed in this paper includes system physical architecture, business architecture, core functions and so on. According to the requirements of relevant specifications, carry out system pilot construction, verify the system performance and functional requirements, and meet the business requirements of the new power system construction scheme. Combined with China's goal of "carbon neutralization and carbon peak", carry out the application pilot construction of integrated power distribution and consumption monitoring system, which meets the integration of power distribution and consumption business. By building the system, the reuse rate of distribution and power consumption data is 100%, and the duration of power fault operation and maintenance is shortened by about 2 hours, which effectively improves the operation efficiency of power distribution monitoring and power consumption system and provides a stable and reliable system solution for new energy access.

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