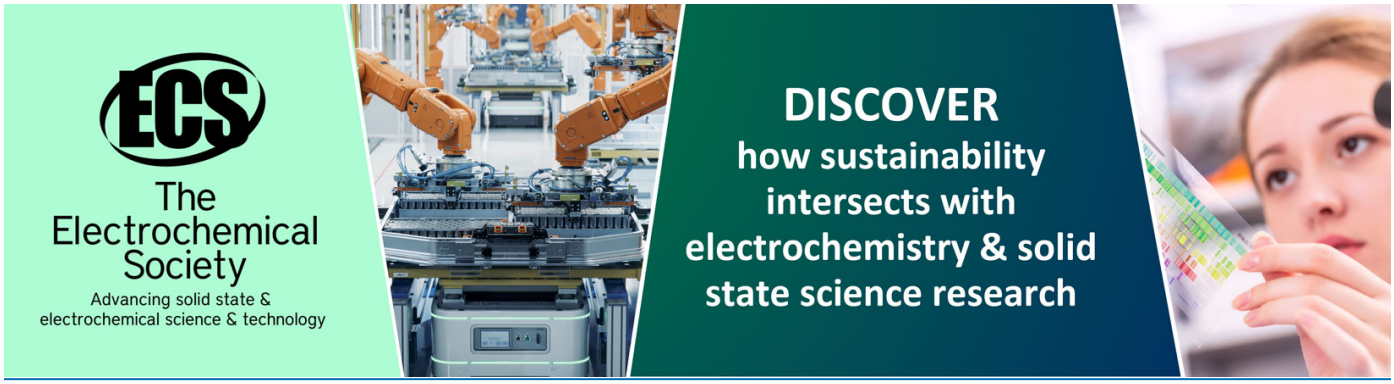
Design and Realization of Online Monitoring System of Distributed New Energy and Renewable Energy



Design and Realization of Online Monitoring System of Distributed New Energy and Renewable Energy

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Abstract. aimed at difficult centralized monitoring and management of current distribu ted new energy and renewable energy generation projects due to great varieties, differe nt communication protocols and large-scale difference, this paper designs a online mo nitoring system of new energy and renewable energy characterized by distributed depl oyment, tailorable functions, extendible applications and fault self-healing performanc e. This system is designed based on international general standard for grid information data model, formulates unified data acquisition and transmission standard for differen t types of new energy and renewable energy generation projects, and can realize unifie d data acquisition and real-time monitoring of new energy and renewable energy gener ation projects, such as solar energy, wind power, biomass energy, etc. within its jurisdi ction. This system has applied in Beijing. At present, 576 projects are connected to the system. Good effect is achieved and stability and reliability of the system have been v alidated.

1. Introduction

With the development of society, the disadvantages of conventional power generation are becoming increasingly prominent [1, 2]. New energy and renewable energy mainly include solar energy, wind energy, biomass energy and small hydro power. They are drawing increasing attention of people due to its characteristics, such as clean, pollution-free and resource regeneration. Development and application of new energy and renewable energy in demand side to form the sustainable energy supply system based on internet information technology and supplemented with grid power supply will become inevitable trend of smart grid development in the future [3, 4].

Currently, new energy and renewable energy generation projects enter rapid expansion phase in China. At present, main problems in distributed energy generation projects are as follows:

①Generation equipment is decentralized, operation environment is complex, manual routing inspection efficiency is low and safety problems cannot be found immediately.

②Voltage shape, short circuit current, power quality and other generation parameters of generation projects are impacted by external environment. The abnormal fluctuation cannot be warned in time, which influences normal using of power consumption equipment [5, 6].

③As for distributed new energy and renewable energy generation projects, types are various, scales are different, deployment locations are scattered, and communication protocols are different. Therefore, they are difficult to be in centralized statistics, management and dispatch.

Above problems severely impede sustainable development of relevant industries and utilization of clean resources. In many regions, "wind and PV generation mode" is abandoned. Therefore, the monitoring platform and data center are in dire need to be built for real time and remote monitoring of relevant data of generation projects to guarantee safe and stable operation of generation projects [7].

Compared with rapid development of new energy and renewable energy, construction of data monitoring and information sharing platform is lagging. In foreign countries, research on online monitoring and analysis of multi-distributed generation projects within regional scope is in start stage, so, the system or the platform developed is inclined to data acquisition and neglects data analysis. At home, most online monitoring and management systems of generation projects monitor the single generation station. The monitoring object is single. There is no report of the real-time monitoring management platform and index system for comprehensive evaluation of operation status and generation capacity of multi-distributed generation projects simultaneously [8-13].

This paper designs a kind of new energy and renewable energy online monitoring system characterized by clear structure, distributed deployment, tailorable functions, extendible applications and fault self-healing performance in demand side and formulates the acquisition and transmission standards for various generation projects to realize the digital and refined centralized management and remote monitoring of distributed new energy and renewable energy generation projects.

2. System architecture design

2.1. Overall architecture of system

Overall architecture of online monitoring system of new energy and renewable energy is shown in figure 1. This system is composed of real-time online monitoring and WEB information release. Real-time online monitoring is responsible for acquisition, collection, monitoring and analysis of power data, environmental data, equipment conditions and other real-time data of distributed new energy and renewable energy (including PV, Biomass and wind power) generation projects. Web information release mainly refers to Web show to government, relevant enterprises and public, supports browse queries anytime and anywhere by PC and mobile terminal equipment, and supports push service of WeChat, APP and other emerging media. The data storage analysis service saves the data acquired by real-time online monitoring system, establishes the data mirror in WEB information release part through the physical isolation device and provides data support to information browse and query.

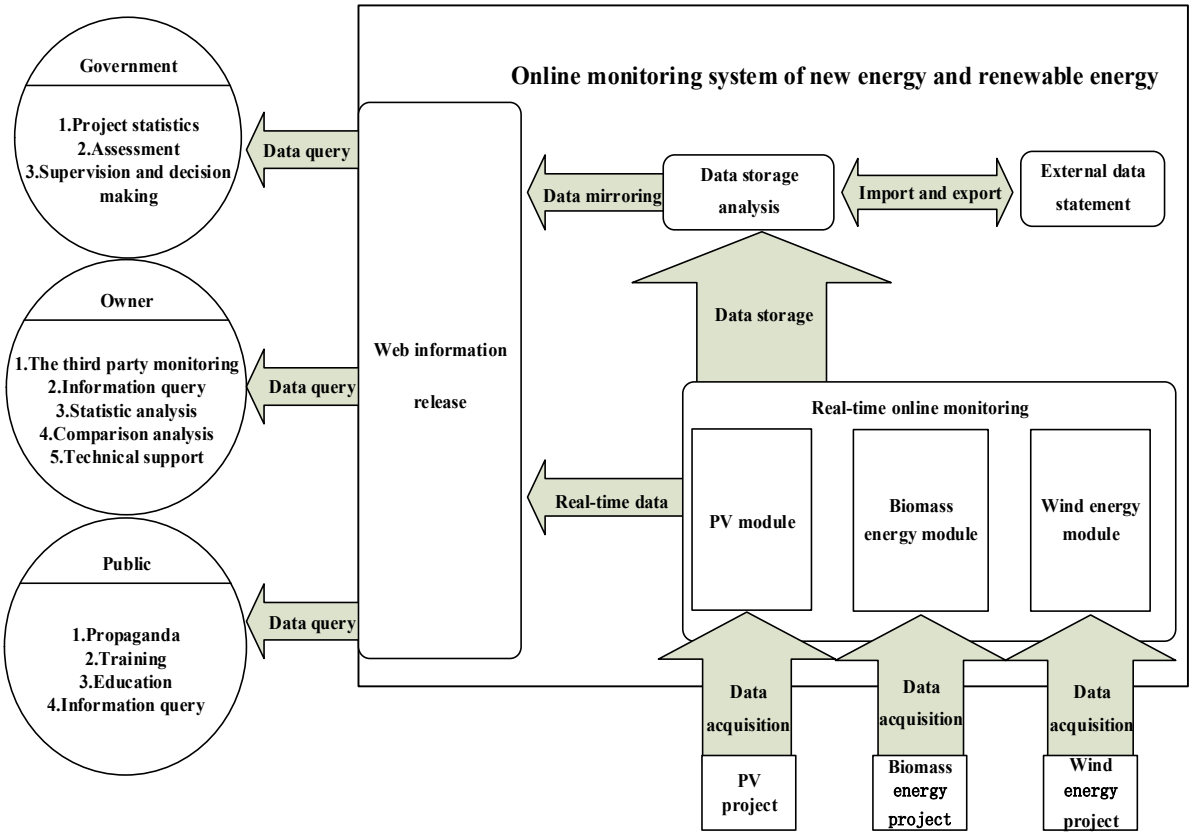

Figure 1. Schematic diagram of overall architecture

2.2. Logical architecture design

Online monitoring system software of new energy and renewable energy is designed pursuant to IEC61970, IEC61968 and IEC61850 grid data information model standards [14, 15]. Its logistic architecture is shown in figure 2. The software is divided into platform layer, data layer, application layer and presentation layer. The platform layer is the core of the system and provides bottom service for realization of the whole system functions; it adopts hierarchical and modular structure design; all modules are independent, provide standard service access or programming interface, provide supports for realization of overall integration of different real-time information and provide universal interface for access of all application functions and integration of the third-party software. The data layer supports various mainstream communication protocols, is responsible for analysis of upload data of generation projects, including data related to equipment, archives, environment and generation, realizes centralized acquisition, storage and management of real-time data, and is the data source of the whole system. The application layer is responsible for further analysis of data, finishes individualized analysis of monitoring data and individualized design of statistics statements for different users and provides data support service for presentation layer. The presentation layer includes presentation of real-time operation monitoring of monitoring platform and presentation of system portal of information release system. Real-time operation monitoring presentation is responsible for real-time dynamic presentation of operation state and generation situation of generation project equipment and receiving the input of administration command of user. System portal presentation responds to the browse, query and information push demand of user at any time and any place.

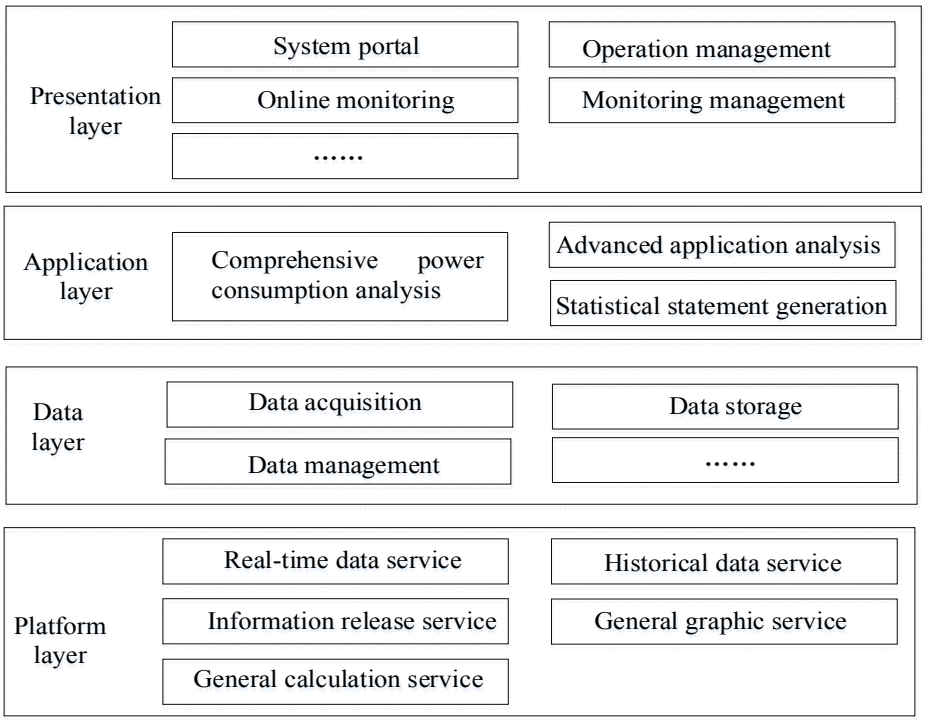

Figure 2. Schematic diagram of logical architecture

2.3. Physical architecture design

Physical architecture of this system is shown in figure 3 and is composed of data center, communication channel and field data acquisition. It is a complete set of complicated system, including computer software and hardware system and other supporting devices and also including redundant data communication connection, environmental control equipment, monitoring equipment and various safety devices.

Data center is the "brain" of the whole system, is mainly composed of data, acquisition, application, WEB and other servers, switches and isolation devices and is responsible for analysis, storage, query display and treatment analysis of data. Communication channel transmits the data acquired by data acquisition terminals to the data center in wire or wireless mode according to the unified protocols. Field data acquisition can be divided into wind generation data acquisition, PV generation data acquisition, biomass generation data acquisition, etc. according to types of generation projects and is mainly responsible for measurement, acquisition and processing of power, environment, work condition and other raw data.

The field data terminals which are deployed in generation project will collect the data from local monitoring devices according to different corresponding data communication protocols of electric energy meter, environment monitoring instrument and other local monitoring devices, process the data according to transmission protocol of communication channel, and periodically send data out through communication channel. The communication channel adopts TCP/IP based exclusive communication protocol and transmits the data to data center in wire or wireless mode. The data center will analyze and store the data and provide data support for business and data application of system.

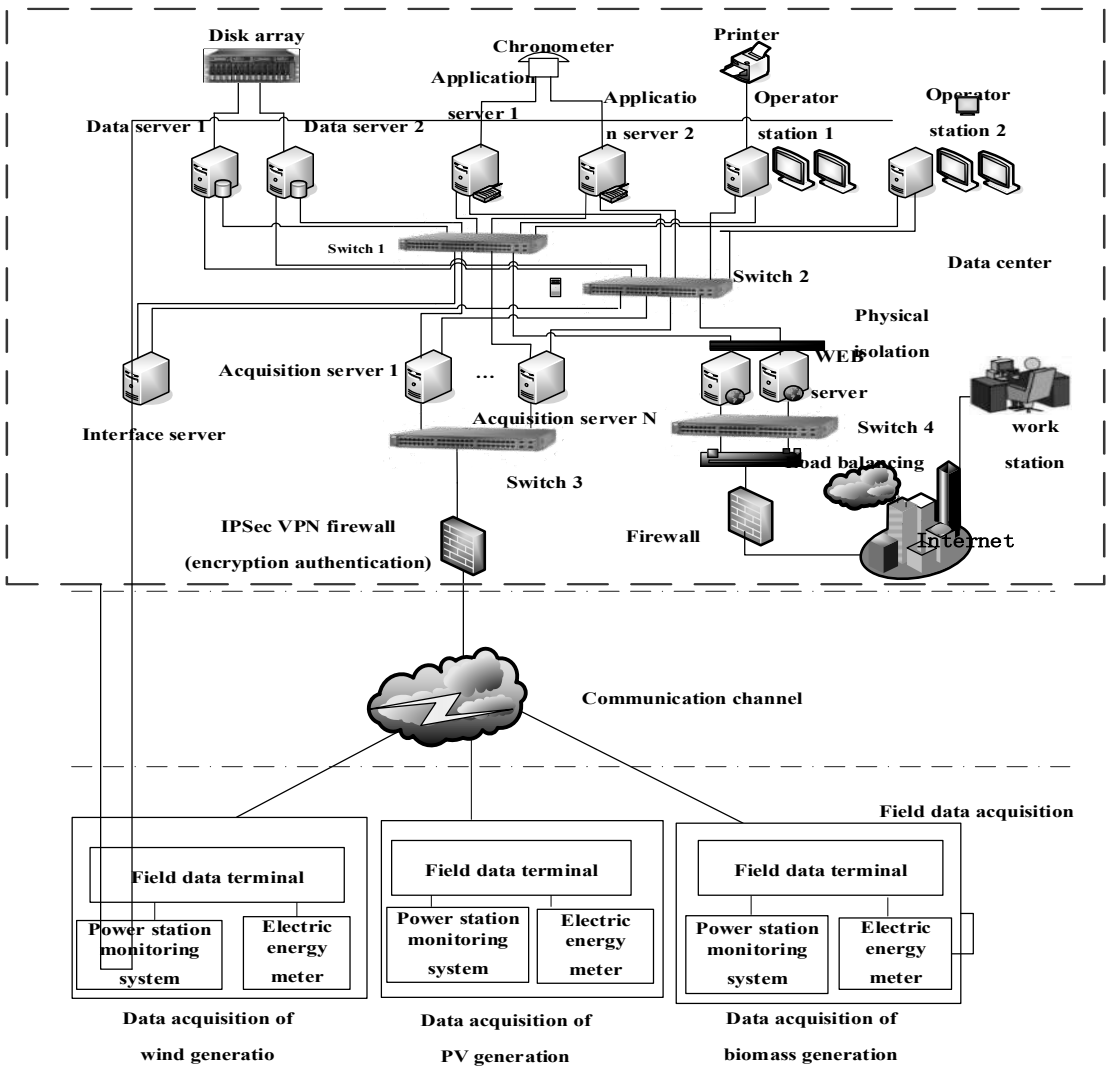

Figure 3. Schematic diagram of physical architecture.

2.4. Key technologies of system

2.4.1. Dual-network balanced shunting technology, this system adopts network data shuttle model with dynamic balanced shunting and supports dual-network mode. Data information is transmitted in dual networks in a balanced way. On one hand, it guarantees rapidness of data transmission. On the other hand, balanced dual-network structure enables normal operation of system in case of failure of any network segment to guarantee reliability of data transmission. Data can select the network node for transmission. If single network of any node is in failure, flow of dual-network passes through the normal network card.

2.4.2. Graph, model and database integration technology, Dynamic graphic display of this system adopts the graph, model and database integration technology based on visualization and full vector. Graph, model and database integration technology based on CIM model is designed according to the principle of facing generation system object, adopts full vector graphical guidance tool, realizes integration of input of graph and database, and can automatically establish the correspondence between equipment of graph and data in database. Graph, model and database integration system can automatically establish the network topological relationship for the whole grid according to the

connection relationship in wiring diagram, which greatly simplifies engineering work and maintenance work, guarantees correctness of maintenance work, avoids human error, guarantees consistency of graph, model and database and reduces the modelling and database building time.

2.4.3. "Soft synchronization" technology, Multi servers of this system adopt the "soft synchronizatio n" technology to guarantee consistency of multi database. Database (soft synchronization) technology changes the traditional clustering technology, adopts soft backup technology, and guarantees consisten cy of data of database in active and standby data server via the copy program in server to reduce the ha rdware costs of the whole system and guarantee the security and consistency of data.

2.4.4. System operation log and self-inspection and self-healing mechanism, this system adopts self-monitoring, self-diagnosis and self-healing technology. The monitoring probes are placed in sensitive regions and key nodes in hardware and software to generate the operation log in real time. Monitoring and warning of hardware, CPU, memory and other system resources can nip in the bud. Active and standby switch can be carried out intelligently for system failure. The core software process is designed with automatic abnormality restart function to actually improve the operation reliability of automatic system.

3. System function design

3.1. System function positioning

This system utilizes modern communication technology for online monitoring and analysis of basis situation, generation capacity, electric energy quality, resource utilization situation and other parameters of new energy and renewable energy (PV, wind, biomass energy, etc.) generation projects and transmits data to data center server system through network for storage, analysis and display of data to realize visualization supervision and dynamic display of real-time data of generation projects.

3.2. System function design

This system is composed of online monitoring system and information release system. Its functional architecture is shown in figure 4.

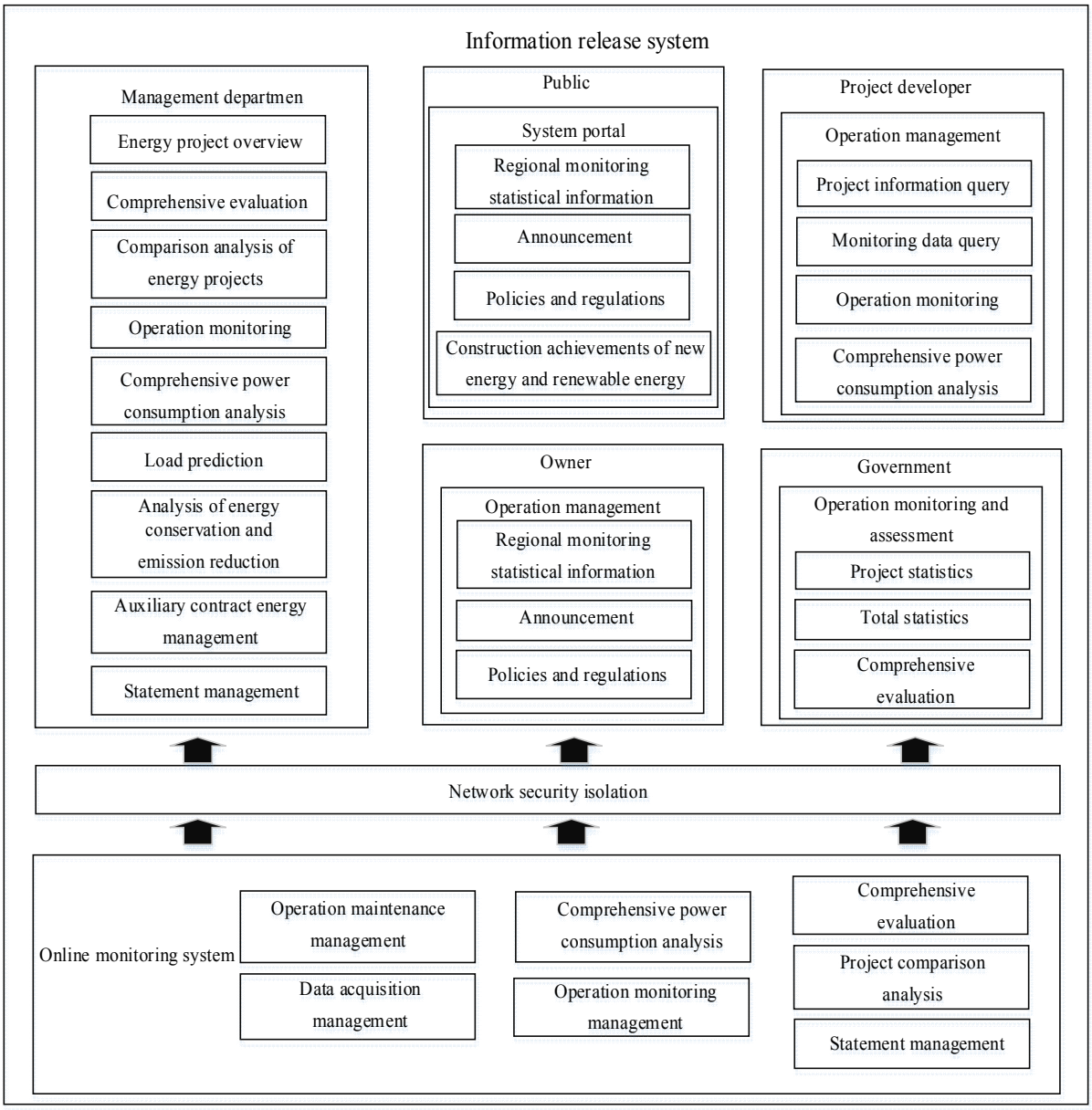

Figure 4. Schematic diagram of function architecture.

3.2.1. Online monitoring system, ① Data acquisition management, Data acquisition function supports various mainstream communication protocols, can realize access, real-time acquisition, interrogation and analysis of meteorology, power generation, power quality and other relevant data uploaded by all new energy and renewable energy projects within its jurisdiction and can realize data filling, import and export function of non-real-time data, such as equipment parameters and archive information, and can conduct maintenance management of archive information, user information and archive hierarchical relationship.

② Operation monitoring management

The operation management includes operation maintenance management and operation monitoring management. The operation maintenance management can mine the information and intelligently warn for online monitoring system and provide more visual and intuitive graphics. The system operation management personnel can conveniently and visually know current operation state of system via

flexible, physical and dynamic mode of data to take more effective and more targeted operation management strategy. The operation monitoring management can realize power station operation monitoring management, power curve monitoring, abnormal power consumption monitoring, power quality monitoring, equipment working condition operation monitoring, operation monitoring and other functions. The comprehensive power consumption analysis can realize the following functions, including generation load analysis, load rate analysis, power energy analysis, three-phase equilibrium analysis, extreme value analysis, power supply reliability analysis and abnormal power consumption analysis.

③ Statement management

The system can sort and make statistics of raw data, user load curve, user management and alarm information according to user, date, terminal and other conditions and display and output in statement form. The statement generated is compatible with Excel format which is convenient for reading of user.

④ Advanced application analysis

Advanced power consumption analysis refers to deep mining and individualized analysis of relevant data aimed at different demands of users and is composed of project comparison analysis and comprehensive evaluation. The project comparison analysis realizes horizontal comparison and analysis of generation projects in aspects of equipment operation state, inverter operation efficiency, PV power station generation efficiency, component generation efficiency, fan operation state, converter operation efficiency and wind power station generation efficiency. The comprehensive evaluation realizes evaluation of operation efficiency, resource utilization capability, general benefit and power energy of generation projects. The comprehensive power consumption analysis provides load analysis, load rate analysis, power energy analysis, three-phase equilibrium analysis, extreme value analysis, power supply reliability analysis, abnormal power consumption analysis of connected projects and other functions.

Besides, this system actively explores the development trend of smart grid in the future and preliminarily explores and applies the functions, including generation load prediction, auxiliary contract energy management and energy conservation and emission reduction effect analysis [16-18].

3.2.2. Information release system, the information release system adopts B/S structure and is responsible for Web presentation of system. It supports access of PC webpage and mobile equipment application, provides the push service of WeChat, APP and other emerging media and is convenient for browse and query of non-real-time data by user whenever and wherever possible. The system classifies users according to their different demands, including public, owner, developer, management department and government. The system will analyze and show the data in different dimensions and perspectives based on the classification. The specific functions include system portal for public, power consumption query and analysis for owner, operation management for developer, energy project overview for management department and operation monitoring and assessment for government.

4. System deployment and application

Online monitoring system of new energy and renewable energy has been deployed and applied in Beijing and has established the unified centralized monitoring platform for PV, wind and biomass power generation projects in Beijing.

The planned connected projects in Beijing are 1,500. According to the communication protocol adopted by the system, acquired index parameters of each project are 200 (including 10 meteorological environment index parameters, 150 inverter index parameters, 10 combiner box index parameters and 10 DC distribution cabinet index parameters). These parameters are reported at interval of 15 minutes. 30% redundancy is reserved. Besides, it can guarantee data storage more than 10 years. Consumption and deployment of system resources are designed mainly based on above mentioned parameters.

At present, the system is successfully on line and connects 576 generation projects. It is planned to connect 1,500 projects by the end of 2017. Reliability of system and robustness of protocol have been validated.

5. Conclusion

The online monitoring system of new energy and renewable energy designed by this paper is based on internet information technology, provides technical services for users, including monitoring, analysis, evaluation, grid connection and information release, and is the monitoring system at user side integrated data acquisition and processing, operation monitoring, real-time analysis, information display and other functional modules.

All new energy and renewable energy generation projects within jurisdiction of this system are acquired in real time in a centralized way and are shown to public.

At the same time of system research and development, acquisition indexes of new energy and renewable energy generation projects are sorted and standardized, the transmission communication protocol is designed, and standardization of acquisition and transmission data of generation projects with different types and scales is realized to provide basis for centralized connection and management of all projects.

At present, this system has been deployed and applied in Beijing and has obtained ideal effect. In the future, the system will gradually explore to connect other clean energies and deeply mine and analyse the data to further promotion of popularization and application of new energy and renewable energy in energy field.

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