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Design and Implementation of Smart Energy Management System

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Design and Implementation of Smart Energy Management System

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Abstract. In order to optimize the energy management of the industrial park, the technical architecture and the function of intelligent energy management system are set up using information technology of use fixed number of year, load, capacity, cost of investment, etc. of various equipment in the industrial park. All the data monitoring, collection and analysis are based on the energy consumption index of scientific management, realizing the optimal operation, the effects of energy conservation and emissions reduction and refined energy management, and promoting the economic benefits of the park. Based on the Guangzhou City Project, in order to improve the comprehensive efficiency of energy use in the park, this paper carries out offline debugging and online commissioning of energy storage equipment in the park.

1. Introduction

With the aggravation of global warming, traditional fossil energy has caused serious damage to human living environment [1-2]. As a major country in the world, China has taken the initiative to take responsibility of changing the human environment and pledged to strive for a peak in carbon dioxide emissions by 2030 and achieve carbon neutrality by 2060[3]. In this environment, energy conservation and emission reduction of industrial parks has become an important path to achieve carbon peak and carbon neutrality. As an accelerator to promote the industry, energy management has become one of the issues most concerned by park operators and managers. With the deep integration of the new generation of information technology and the application of park management, the development of energy Internet has been promoted [4-5]. Energy Internet realizes the two-way communication between information flow and energy flow through intelligent energy management system. Intelligent energy is the product of deep integration of energy technology and information technology. With the help of information technology, building a smart energy management platform in the park has become an inevitable trend to continuously promote energy conservation and consumption reduction and to realize refined management of energy consumption, as well as an important part of the smart park [6]. In the intelligent energy system, the types and application of modern information are constructed based on the pluripotent coupling technology and Internet network, aiming at the energy demand of end users such as electricity, heat, cold and gas. Through the intelligent energy management system, the longitudinal transverse pluripotent "source-network-load-storage" coordination and bidirectional interaction between supply and demand are realized. [7].

Based on the construction project of Guangzhou Smart Park, this paper conducts online operation and debugging of the energy system in the park. It is of great significance for the rational energy consumption, economic growth and environmental protection of the park to design a set of intelligent energy management system by editing the input information of main energy storage equipment on the

web page, integrating the public energy types and energy prices such as electricity, gas, heat and cold energy, and calling the online optimization operation algorithm model.

2. Energy management system architecture

2.1. Energy management system

To achieve intelligent energy operation scheduling, real-time energy supply and demand balance, health management of equipment, accurate prediction of load, the ensurance of safe and stable operation of the system, it is necessary to call optimization algorithm model through web page and MQ interface to optimize the operation management[8], scheduling and intelligent control of energy structure. Therefore, a comprehensive energy management system in the park was developed. The system is mainly based on Windows system and Java language development, Java is an Internet-oriented programming language. With the continuous maturation of Java technology in the Web, Java has become the preferred language for Web application development. Through the establishment of the smart energy management system, managers have a detailed and in-depth understanding of the energy structure and energy utilization of the entire park, which also provides a data basis for the energy security of the park to guide the low-carbon ecological construction.

2.2. Energy management application architecture

Aiming at the coordinated control of various energy sources such as cold, heat, electricity and gas in the comprehensive energy system of the park, starting from the actual situation of energy management and information construction in the park, the overall design is carried out from the overall application architecture and implementation architecture to build a set of intelligent system architecture suitable for the energy management of the park.

According to the requirements of the project, the application architecture is mainly divided into three layers: user parameter input, intermediate data interaction and data visualization display[9], to build a smart energy operation and scheduling system that balances energy supply and demand in real time. User parameter input can read data through CSV, Xlsx and other table files or directly input data on the Web page. Intermediate message passing requires the input parameters to interact with the model algorithm in the form of JSON files. Finally, it is necessary to visually display the data and result data of the algorithm running process.

2.3. Energy management technology Architecture

Energy management technology architecture adopts B/S architecture, that is, Browser request, Server response mode. The advantage of B/S architecture is that users only need to access the data, pictures, text, animation and other information generated by the Web server on the Internet through the browser. This architecture unified the client, centralized the core part of system function realization on the server, and simplified the system development and maintenance. Through B/S architecture, the energy management system is divided into interface display layer, business logic layer, data access layer and infrastructure layer[10], as shown in Figure 1.

2.3.1. Interface display layer.

Web Server is developed by Spring Boot, and View is developed by vue. js + Element UI. The purpose of separating the front and back ends is to make the front and back ends achieve faster coupling. The core idea of front and back end interaction is that the front end Vue page invokes the back end Restful API interface through Axios and uses JSON format for data transmission.

2.3.2. Business logic layer.

The business system provides business services through Tomcat, a micro server. Tomcat, as a Web application server, is responsible for processing customer requests, sending requests to servlets, and sending the responses of servlets back to customers. The user enters the url into the browser and the request is sent to the native port 8080.

2.3.3. Data access layer.
It adopts open source technical framework to provide software development support, and provides technical support for business logic development by integrating advanced development technical framework and technology. The back-end Spring Boot is used as the integration framework, and the database is connected by integrating JDBC, MyBaits and other technologies. It mainly includes relational database MySql, in-memory database Redis and real-time database.

2.3.4. Infrastructure layer.
Some interface functions required by Vue front-end page are realized by using the Element UI of on-site rapid prototyping component. Echarts is an open source visualization library that provides many commonly used diagrams, rich interaction, and highly customizable data visualization diagrams to show dynamic changes in data.

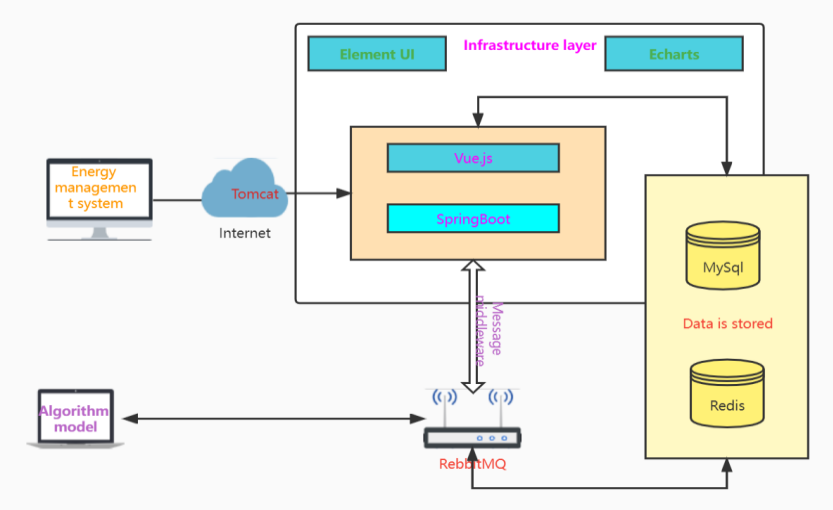

Figure 1. Energy management technology architecture.

3. System function

3.1. Energy management technology Architecture
The input of the system structure is to draw the topology diagram of the energy system in the form of visual editing. According to the requirements of the project, the park has five kinds of equipment, namely photovoltaic, battery, power grid, electric refrigeration and electric heating. The topology diagram supports the drag and drop of energy device nodes, connecting nodes with cables according to the specified rules, and editing the cable information through the "Device and Routing Information Input" function described in the previous section. Figure. 2 is an example of topology drawing of the system structure.

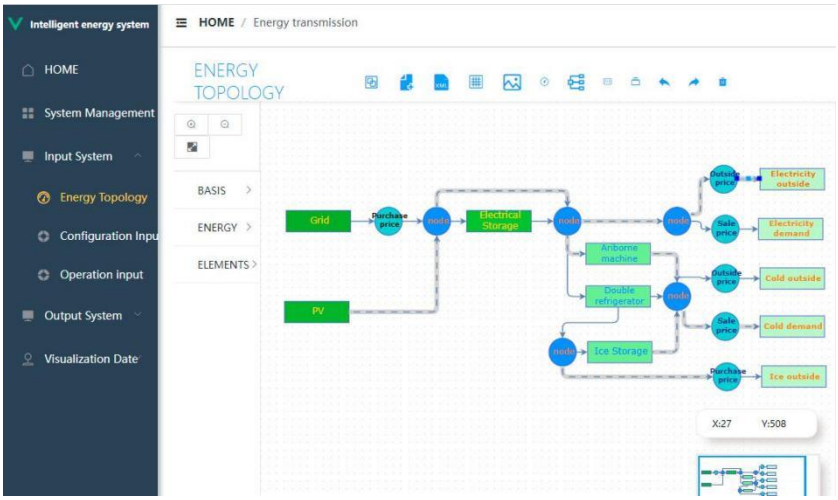

Figure 2. System structure topology.

3.2. *Information interactive transmission*

The interaction of energy equipment data is to parse all kinds of initialization information of equipment in topology into JSON files, and use message middleware RebbitMQ to transmit and receive data. FIG.3 shows RebbitMQ transmitting and receiving asynchronous messages through AMQP advanced message queues. The Web page parses the energy equipment information input by users for JSON data and stores the data. The JSON file is passed to the algorithm model through RebbitMQ, the message middleware. Finally, the Web page calls the calculated result data again through MQ interface. Figure.3 shows the structure of the RabbitMQ messaging process.

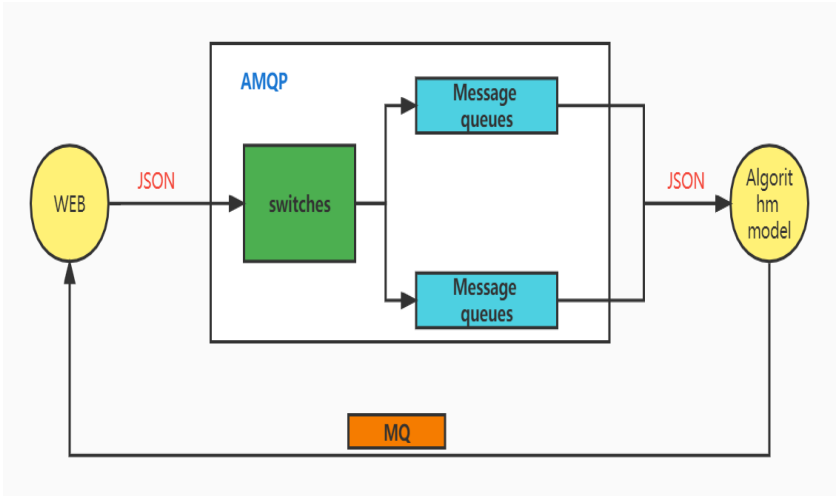

Figure 3. Message middleware.

3.3. *Visualization of output results*

Echarts component is introduced into the front-end Vue. Echarts is an open source chart library, and the bottom layer relies on the lightweight Canvas class library ZRender, which can meet the highly personalized customized data visualization chart. The engineering operation characteristics of power supply, power grid, load and energy storage modules in the integrated energy system of the park are studied, such as efficiency curve, load curve, output curve, conversion curve of cold/heat/electricity/gas and economic benefit analysis of the energy management system of each equipment.Figure.4 is the pie chart of the total load ratio distribution of each device.

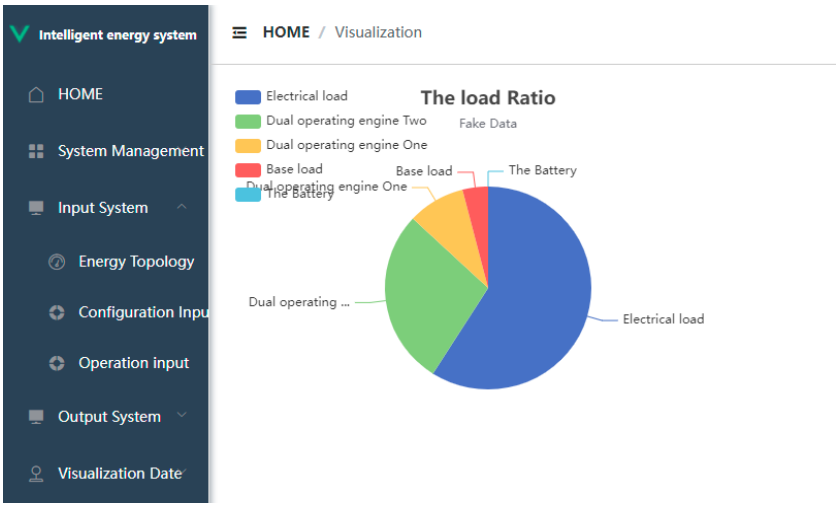

Figure 4. Load proportional distribution.

4. System advantage

The core of rational and optimal utilization of energy is multi-energy scheduling. According to the production plan and actual energy consumption per unit, the optimal energy scheduling can be realized in order to minimize the overall energy consumption cost under the condition of meeting the production energy consumption. Compared with the traditional energy efficiency management system, the intelligent park energy management system has the following advantages.

4.1. *Technology maturity, scope of application and security*

The system can be designed according to different scenarios. It can be safely isolated from the process control system to ensure the energy security of the process. The intelligent energy management system outputs optimization strategies and adopts mature management mode to ensure the energy saving and emission reduction of the park.

4.2. *Feature customization and visual interaction techniques*

The function customization and visual interaction technology of intelligent energy management system in the park are realized. According to the characteristics of electric energy system in industrial park, such as cooling, heating, load fluctuation and diversification of energy supply, in terms of online data collection and analysis technology of large energy, the intelligent visual interactive technology solution of industrial park is formulated, and the energy management system is built into the intelligent energy management platform of actual load and operation effect, so as to realize the refined management of energy system and improve the overall energy efficiency ratio.

4.3. *Energy efficiency*

Through information and intelligent control technology and strategy, peak cutting and valley filling of heat and electricity can be realized, and the safe and stable operation of energy supply system can be realized. Combined with the demand changes of cold, heat and power loads, various energy technologies and energy storage units are integrated. Based on the electricity consumption, time-sharing electricity and heat, electricity load characteristics and power characteristics, the optimal operation strategy and demand side load control scheme of the energy utilization module are comprehensively analyzed and determined, and the technical scheme is comprehensively evaluated from energy efficiency and economy.

5. Conclusion

Through testing the intelligent energy management system, and obtains the following conclusions:

(1) An intelligent energy management system based on the front-end Vue.js open source framework and the back-end Spring Boot open source framework is proposed, and the input model, transmission

model and output model of corresponding devices in the system are established. Meanwhile, the system has expansibility, and the operation conditions in different scenarios can be realized by changing different device models in the topology. It can also be applied to other parks.

(2) Element UI component, Mxgraph component and Echarts component are introduced into the front-end Vue framework. Based on these lightweight components, modules such as system login interface, user rights management, device flow management and data visualization display are developed. RabbitMQ is configured in the back-end Spring Boot framework and it is used as a messaging middleware to interact with JSON data.

(3) Using Using the relational database MySQL to store the data running in the system, it can support a variety of operating systems, provide a variety of API interfaces, and support the development of a variety of languages. At the same time, the in-memory database Redis is used to help storage. When the amount of data is too large, the data can be retained, so that when the cache stops and all the system restarts, all the data still exists.

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