System Structure and Operation Analysis of University Energy Conservation Supervision Platform

Na He, Guohui Feng, Cheng Wang and Lin Wang

Abstract Through the real-time monitoring of key cities and buildings across the country, energy consumption statistics, energy consumption auditing, energy efficiency publicity and energy consumption analysis were adopted to realize the management mechanism of energy conservation operation of national large public buildings. However, the operational analysis methods of the energy conservation monitoring platform and its guiding significance for the energy conservation renovation project have not appeared after construction. This study aims at summarizing the problems existing in the operation and use of the energy conservation monitoring platform and proposing the guiding significance of monitoring data analysis for energy conservation reform. This paper introduces the system architecture and main functions of the energy conservation supervision platform of a university in Shenyang. Based on the measured results in operation, the energy consumption data of the campus is statistically analyzed and compared, and the application effect of the energy conservation monitoring platform is analyzed in combination with the energy conservation renovation project.

Keywords High school energy saving · Energy-saving supervision platform · System structure · Operation analysis

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Z. Wang et al. (eds.), *Proceedings of the 11th International Symposium on Heating, Ventilation and Air Conditioning (ISHVAC 2019)*, Environmental Science and Engineering, https://doi.org/10.1007/978-981-13-9528-4_67

1 Introduction

Since 2007, China has vigorously promoted the establishment of the energy conservation supervision system of public institutions. Institutions of higher learning are main places with dense personnel and large mobility in today's society [1, 2]. With the continuous expansion of the construction scale of colleges and universities, the energy consumption of different kinds of buildings and equipment in the campus is also increasing, and the energy consumption is on the rise. Therefore, it is imperative to promote campus energy conservation and emission reduction by building energy-saving campuses. At present, under the vigorous promotion of the ministry of education and the ministry of housing and urban–rural development, more than 200 colleges and universities in China have completed or are building the energy-saving supervision platform for campus [3, 4], and there are also more than 10 in Shenyang. By building an energy consumption supervision platform, colleges and universities can realize the monitoring for the measurement of the energy consumption of the campus, master energy consumption data, analyze the problem of energy consumption, raise the awareness of energy conservation and reduce energy waste, tap the potential of energy conservation and reduce energy consumption, which can provide reliable data support and effective method for further improving the campus energy efficiency and level of energy management. Energy consumption monitoring platform itself does not have energy-saving effect. It is based on a powerful database of energy consumption, and drawing a certain conclusion through reasonable statistics analysis and scientific analysis methods. It can give guidance to the energy managers to achieve the goal of energy saving and consumption reduction through energy-saving transformation, adjustment of equipment operating time and conditions, behavioral energy saving and other ways. Therefore, the analysis of energy-saving operation is particularly important in the use of energy-saving supervision platform [5, 6].

2 The System Architecture of the Energy Conservation Supervision Platform

2.1 Energy Conservation Supervision Platform System Overview

The college energy-saving supervision platform system is built on the basis of electricity regulation system, water supervision system, heat supervision systems, and building energy efficiency supervision system. These systems adopt the advanced data fusion, data mining, and remote dynamic graph generating technology, extracting real-time data from energy regulatory platform of each subsystem, and forming comprehensive data analysis. Through the comprehensive processing and calculation of massive energy consumption data, various statistical charts are formed to reflect

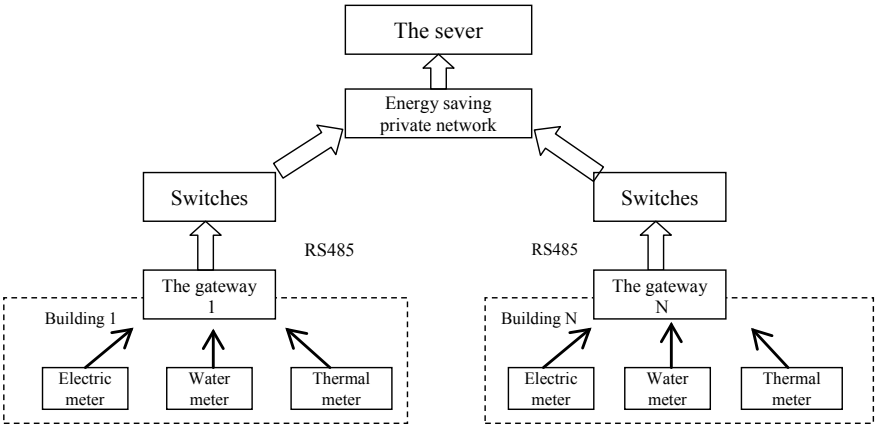

Fig. 1 Framework diagram of energy conservation supervision platform

the comparison of historical energy consumption and future energy consumption trend in real time. The system has rich functionality, including classified building energy consumption, energy consumption of per unit area, comparison of energy consumption by categories and items, energy consumption analysis and prediction, energy-saving evaluation, carbon neutral calculation and other functional modules with comprehensive functions. The specific contents are as follows:

1. Building energy consumption monitoring terminal system, including building electricity system monitoring, water quantity monitoring, and heating monitoring;
2. Campus network and data transmission system;
3. Data center of energy consumption, including server system, data display system, data analysis system, etc.

The energy conservation supervision platform involved in the study includes the collection and monitoring of data of electric energy, water resources and heating. The special network of the energy conservation platform is set up for data transmission. The frame diagram of the platform system is shown in Fig. 1.

2.2 Platform Software System Framework and Functions

The data of energy consumption classification and itemization are sent to the upper-level data center mainly through "energy consumption data reporting subsystem." The system administrator can freely set the time point or cycle for data reporting. The information communication in the data center is mainly completed by the "message management subsystem," and relevant information is distributed via SMS, email, or RSS via the Front View unified messaging platform.

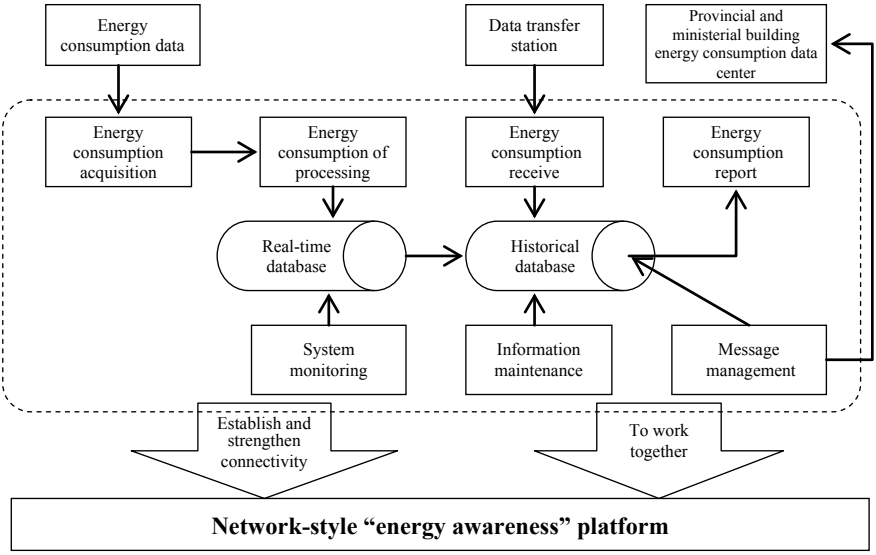

Fig. 2 Software system structure of the energy conservation supervision platform

The normal operation of the monitoring data center system and the building monitoring instrument for 7 * 24 h is completed by the "system monitoring subsystem." It mainly provided the functions including the running state monitoring of subsystem, the energy monitoring running state monitoring of gateways, the energy sensing equipment running status monitoring of buildings, the real-time monitoring of the communication report, and all operating behavior audit and trace of internal operation state event. The software system structure of the energy conservation supervision platform is shown in Fig. 2.

2.3 Main Functions of the System

The monitoring scope covers campus teaching buildings, office buildings, living buildings, sports venues, scientific research demonstration buildings, and other buildings. The first-level measurement monitoring rate is over 90%, and the second-level measurement monitoring rate is over 60%. There are 62 gateways, 919 electricity meters, 251 water meters, and 9 heat meters in the system. The application service functional structure of the system is shown in Fig. 3.

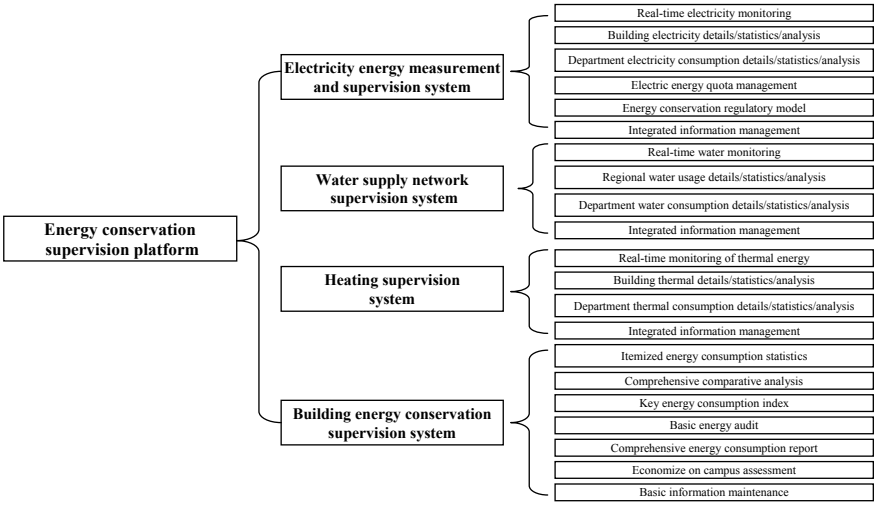

Fig. 3 Main functional structure of the system

3 Operation Analysis and Energy-Saving Reform of Energy-Saving Supervision Platform

3.1 Real-Time Power Supervision

The real-time electricity monitoring function can find the electricity problem in time, which has the advantage of accuracy and intuitionism. Figure 4 is the electricity 72-h histogram of a laboratory from July 2 to July 4 in 2016. It is clearly seen that the electricity consumption forms a certain trend every day. On July 2, the peak of electricity consumption concentrated at 9 am to 8 pm, which belongs to the normal use case. And on July 3, there was a persistent peak after 8 pm, which indicates that the laboratory has standby power consumption at night. This is an abnormal use case of energy. In this campus, there are more than 50 laboratories like this. According

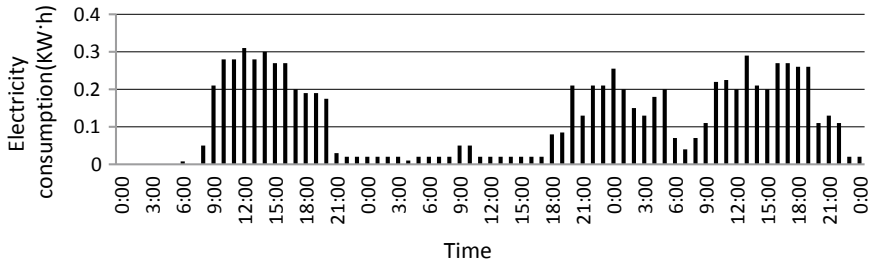

Fig. 4 The electricity 72-h histogram of a laboratory

to the daily standby power consumption of 5 kW h in each laboratory, it will waste 54,750 kW h in a whole year. According to the school's minimum electricity standard of 0.5 Yuan, the annual energy cost will be wasted of 27,375 Yuan. After investigation, it was found that the laboratory administrator forgot to turn off the experimental instruments at night, and relevant departments were alerted to make rectification.

3.2 Analysis of Building Electricity Consumption

The building electricity analysis function of energy-saving supervision platform can analyze the school annual electricity utilization according to different electricity properties, as shown in Fig. 5. At present, the system divides electricity consumption into three categories: public electricity consumption, domestic electricity consumption and teaching electricity consumption. Among them, public electricity use includes public infrastructure, public buildings, public venues, public laboratories, etc. Living electricity includes student dormitory, bath, canteen, and other living areas electricity. Teaching electricity includes public classrooms and outside the classroom public corridors and other areas of electricity. It can be seen from the figure that public electricity consumption is the largest, which is close to 10,000 kWh. Domestic electricity accounts for one-tenth of public electricity, while teaching electricity accounts for the least, accounting for one-fifth of domestic electricity. It can be seen from the figure that the public electricity consumption is huge, and it needs to carry out targeted transformation of power saving through investigation and analysis.

The building electricity analysis function can also be used for statistical analysis of individual buildings. The energy consumption of each energy-using part can be arranged in ascending or descending order. The energy consumption data of all monitoring points in the building can be inquired in any period of time, and a report can be generated.

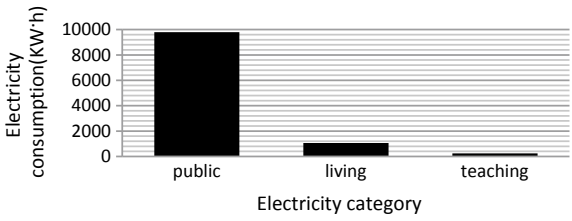

Fig. 5 The electricity 72-h histogram of a laboratory

3.3 Reconstruction of Building Electricity

The school analyzed the energy use situation through the energy conservation supervision system, and put forward suggestions for energy conservation transformation. From 2014 to 2017, the school implemented a series of energy conservation transformation projects. It installed a total of 332 "pzk-32f intelligent light controllers" for 76 classrooms in the teaching area; four sets of "lighting intelligent power saving devices" were installed in the student dormitories; more than 5800 lamps in the student apartment were replaced by LED energy-saving lamps; 112 corridor lights in teaching area and experimental area were transformed into sound and light control lights; the 91 110-w high-pressure sodium lamps in the courtyard were replaced by 23-w energy-saving lamps. Through the transformation of lighting facilities, the annual electricity saving rate of the school reached 12%. Through the energy-saving transformation and installation of energy-saving equipment in recent years, the electricity consumption has been significantly reduced. It can be seen that the purpose of energy saving and consumption reduction can be well achieved by combining energy-saving regulation with energy-saving transformation.

3.4 Real-Time Regulation of Water

The real-time monitoring function of water use is similar to that of electricity use, which facilitates the rapid detection of problems and avoids energy waste. For example, a water meter in the cooking room of the school canteen ran continuously after dinner time on December 7, 2017, until night, which was an abnormal situation of water consumption. The system issued an alarm. After on-site inspection by maintenance personnel, it was found that the water pipe was broken, and the data returned to normal after repair. According to statistics, through this function, the problem of running, dripping, and leaking was found and solved more than 30 times in 2017, effectively reducing the waste of water resources by more than 50 tons (Fig. 6).

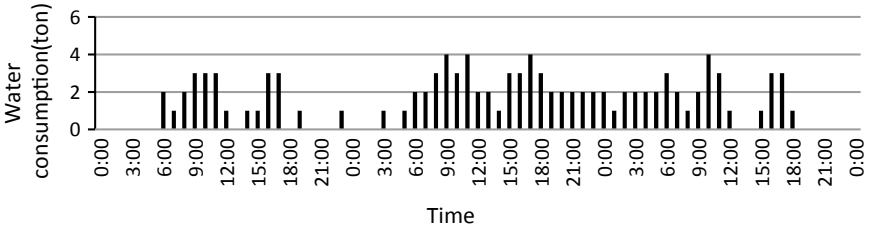

Fig. 6 The water 72-h histogram of a cooking room of the school canteen

3.5 Water-Saving Reconstruction of Buildings

Through the promotion and application of the energy conservation supervision system, the school has vigorously promoted the transformation project of water-saving facilities, and the utilization rate of water-saving appliances on campus has reached 85%. In early 2018, the school has reformed the card-swiping metering system for the bathing room, and the annual water saving has reached over 10,000 tons. From 2017 to 2018, the fire piping system was completely reformed to solve the problem of leakage, and the annual water consumption was reduced by more than 13,000 tons.

4 Problems Existing in the Operation of Energy Conservation Supervision Platform

According to the current situation, for most colleges and universities, the energy conservation supervision platform is only a tool for getting statistics without data analysis and effective energy conservation transformation. And the energy conservation effect is not obvious enough. Due to the changes in teaching functions and using departments, the owner of terminal devices often changes. If the communication is not timely and the platform system does not make a new division, it will bring great inconvenience to the work of energy consumption statistics, analysis, and charging. In many schools, the energy management organization is single, and the responsibilities of management personnel are not clear, while the energy management system is not systematic, and the management means are backward. Under the support of special national funds, most schools have completed the construction of energy conservation supervision platform within a short period of time, and run stably within a certain period of time. But after a few years of operation, there were no longer any funds or manpower input, so the energy conservation supervision platform could not continue to play the role it was designed to play.

5 Suggestions for Improvement in the Energy Conservation Supervision Platform

Except for the conventional energy sources such as water and electricity, the variables such as heat, temperature, and flow should be added to facilitate more comprehensive statistics and analysis of energy use, so as to make a reasonable energy-saving plan for the school yard. By installing smart meters with prepaid functions, energy users can pay energy consumption fees by themselves in advance, which saves time and improves working efficiency. At the same time, it can also prevent individual users from defaulting on energy consumption fees to a certain extent and avoid

the problem of charging difficulty. For some special energy users, such as scientific research institutes and large laboratory and commercial users, the management should be different. Different billing modules can be set directly in the system of energy conservation supervision platform by adopting the charging method of step electricity price and water price, and the implementation of "who use who paid, and who use more energy will pay more" can be implemented. Energy conservation management should be further strengthened, and energy management system should be improved, and there should be clear responsibilities and division of the labor of different energy management positions. And special personnel should be arranged to be responsible for the operation, use, maintenance, and other work of the energy conservation supervision platform.

6 Conclusion

The construction and improvement in university energy-saving supervision platform can effectively measure and monitor the energy consumption situation of campus, put forward energy-saving renovation plan combined with scientific and reasonable analysis, to realize the purpose of energy conservation of campus and reduce emissions. It can also achieve the purpose of energy saving and waste reduction fundamentally through effective operation analysis and energy-saving transformation. At the same time, it can make full use of energy-saving regulatory means to integrate related resources, and building the digital and wisdom campus.

Acknowledgements The research work is supported by National Key R&D Program of China (2017YFB0604000).

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