Research and Development of Energy Consumption Monitoring and Operation System for Campus Training Equipment

Shuahua Chen
Chongqing City Vocational College, Chongqing China
Corresponding email: chencaihua@cqcf.com

Abstract: With the vigorous development of education in China, the energy consumption of campus training equipment, as a microcosm of social energy consumption, has attracted more and more social attention. The traditional energy consumption meter reading measurement method has been difficult to meet the requirements of energy-saving campus construction in colleges and universities because of its low efficiency and poor accuracy. Taking the energy consumption monitoring construction project of training equipment in a school as an example, this paper studies the system architecture and scheme design of energy consumption monitoring platform construction based on Internet of things technology and cloud platform technology. The scheme realizes the functions of real-time monitoring, statistical analysis, energy consumption early warning, quota management and so on, so as to realize the cloud management of electrical safety hazards.

1. Introduction
With the continuous development of national higher education, colleges and universities have gradually become one of the key energy consumption fields in China. Therefore, it is imperative to promote energy conservation in colleges and universities and build energy-saving campus training equipment. The full realization of intelligent energy management has become an important part of smart campus training equipment construction and smart logistics management [1-2].

With the comprehensive development of teaching and scientific research, the energy consumption expenditure of the university is increasing. It is urgent to carry out energy conservation and control and green emission reduction through advanced management means. The school management department needs an efficient, real-time, stable and reliable management system to realize the control, alarm, fault location and safety monitoring of all links in the process of energy consumption. It can maximize the role of energy management and ensure the rational use of energy by teachers and students. In order to understand and master the energy consumption and energy consumption in a more effective, convenient and intuitive way, and efficiently select a more energy-saving form of energy consumption.

2. Overall scheme design of monitoring system
The energy consumption monitoring system of training equipment mainly transmits the collected energy consumption data to the energy consumption monitoring system server through the communication network. It can make a data basis for the energy conservation of campus training equipment. The overall architecture of the energy consumption monitoring system includes interface display, data integration, comprehensive energy consumption management, comprehensive energy efficiency management,
platform engine, auxiliary analysis and decision-making, as shown in Figure 1.

Figure 1. overall architecture of energy consumption monitoring system

Comprehensive energy consumption management includes energy consumption quota and benchmarking and energy consumption detection and review. Auxiliary analysis and decision-making are to provide corresponding analysis and decision-making data for the energy consumption monitoring system in the energy consumption monitoring system of colleges and universities, when the energy consumption monitoring system carries out energy-saving potential analysis and decision-making according to energy efficiency [3-4].

3. Cloud platform scheme design
The campus energy consumption monitoring and operation security management system takes the Internet of things intelligent terminal, cloud computing and big data technology as the core. The real-time monitoring parameters involved in the system include residual current (leakage), temperature, current, voltage, frequency, power and power consumption at the load end of low-voltage distribution line [5-7].

In the scheme, big data technology is used to analyze the historical data of various power consumption parameters in real time, predict, warn and alarm the potential electrical safety hazards of the monitored lines. And it can push the advance (alarm) information to the center and users through Web terminal, APP application, GSM short message and telephone secondary alarm, so as to realize the cloud management of potential electrical safety hazards. The overall framework of the cloud platform is shown in Figure 2.

Figure 2. overall framework of cloud platform

The energy consumption mode and decision tree method are determined according to the energy consumption, so as to establish the energy consumption real-time monitoring method. Based on the data mining technology this method is used to identify and confirm the existing energy consumption mode based on the energy consuming body. Thus, it can establish the corresponding energy consumption mode decision tree according to the identification results, and analyze and matches the real-time energy
consumption data according to the corresponding energy consumption mode and decision tree. Then, it is determined whether the energy consumption data collected in real time is abnormal according to the energy consumption mode and historical data. The specific process is shown in Figure 3.

![Figure 3. monitoring chart of energy consumption data collected in real time](image)

### 3.1 Real time monitoring of electrical data
Electrical data parameters of power lines include current, voltage, cable temperature and residual current (leakage). It is monitored in real time in the system for hidden danger diagnosis and troubleshooting. When the monitored data is abnormal, the system can prompt and eliminate the hidden danger of power consumption by means of mobile app, computer Web terminal, mobile SMS push alarm information, 24h online duty and alarm telephone notification service. Finally, real-time early warning of safety information and early warning before fire are realized. In case of extreme conditions, the on-site circuit shall be cut off at the first time through the remote power-off function of mobile phone app (which shall be applied separately).

### 3.2 Data statistical analysis alarm
For 220V and 380V low-voltage distribution system, it can monitor the relevant power consumption data of key nodes such as distribution cabinet, secondary cabinet and terminal distribution box. It can collect three-phase current, voltage, four-way temperature, residual current, three-phase power factor, total power factor, power statistics, peak, average and valley power, voltage frequency, active, reactive and apparent power. It mainly includes real-time monitoring, hidden danger early warning, safety daily report and statistical analysis function. It can achieve 7×24h all-weather online monitoring, first level alarm, two-level hidden danger early warning, and various notification methods (SMS, message push, file log). Rich statistical analysis reports solve the problems that manual personnel cannot be on duty all day and all time, and concealed works are difficult to monitor.

### 4. Hardware scheme design of energy consumption monitoring system
The data acquisition method adopts the automatic acquisition method, which mainly carries out real-time data acquisition for objects such as temperature, humidity and light intensity. The hardware part of the system includes SHT10 temperature and humidity sensor, infrared sensor, photosensitive resistance, LCD and STM32 development board. The software part, the upper computer, adopts LabVIEW. The basic process is shown in Figure 4.
Figure 4. hardware scheme design of energy consumption monitoring system

The SHT10 temperature and humidity sensor collects indoor temperature and humidity data. The infrared sensor can sense whether someone has passed. The photoresistor is used to detect whether the indoor light intensity exceeds the set light threshold. These three devices are connected to the STM32 development board, which uses the control algorithm above STM32 and uses them for data collection. Then, the collected data is transmitted to the upper computer through the serial port module configured with peripherals. The data collected by the serial port is simply processed and stored by using the program written in LabVIEW, and displayed on the front panel and the LCD of STM32.

4.1 Temperature and humidity sensor module

SHT10 is a single-chip digital temperature and humidity sensor, which has accurate and reliable measurement data and long-term stable measurement performance. Its main structure is capacitive polymer humidity measuring element and energy gap temperature measuring element, and is equipped with an A/D converter and a two-wire data interface.

SHT10 temperature and humidity sensor puts the signal processing circuit and sensing elements together on a micro circuit board to output the digital signal in the format set by the user.

After the SHT10 sensor is powered on, the state of the excitation sensor is restored. No command operation is performed during the state recovery. After the state is restored, the data can be read and written. The serial clock input (SCK) pin is the synchronous clock for communication between MCU and SHT10. The serial data (data) pin is a three-state gate, which is used for data transmission between MCU and SHT10.

Pin 1 on the chip is power ground (GND). its power supply voltage is generally in the range of 2.4 to 5.5v. When using this chip, a 100nF decoupling filter capacitor is generally connected in parallel between the power pin and the power supply. Pin 2 is a serial data signal (data), and its internal is a three-state structure for reading data. When it sends a command to the sensor, the serial data is valid on the rising edge of the clock signal and remains constant at the high level. And the data changes after the falling edge. The microprocessor must drive the serial data to work at low level, otherwise the signal conflict will occur in the system. Pin 3 is SCK signal and its function is serial clock input. It can keep the communication between the sensor and the microprocessor synchronized. Pin 4 is the power supply (VDD). NC must remain airborne. The circuit diagram of SHT10 is shown in Figure 5.
4.2 Design scheme of load current waveform acquisition circuit

For the safety monitor and control switch of conventional power consumption, the system product installed in the electric field can form the system network. It needs to timely repair or replace the equipment with defects and aging operation, limit the use of illegal electrical appliances in specific places, and realize the automatic power off of no one on duty, so as to prevent unnecessary trouble caused by equipment electrification when no one is monitoring. In general, it can save electricity, monitor electricity and effectively use electricity.

If the current curve characteristics in the circuit are tested, it can be extended that the functions of high efficiency and energy saving, time-sharing power consumption, energy conservation and emission reduction, safe power consumption and so on are reasonably integrated with the functions of campus energy consumption monitoring system. According to the functional requirements, the expansion board circuit is composed of current waveform acquisition, synchronization signal circuit, control circuit and power management module circuit.

4.3 Design of current waveform acquisition circuit

As shown in Figure 6, through R20 sampling resistor, the current signal of the load is sent to the two inputs of the operational amplifier in the form of difference, so as to amplify the weak current signal in the load circuit. STM32 processes the data through a certain fuzzy algorithm to obtain the information required by the system.

5. Conclusion

This paper studies the system architecture, design scheme and function realization of the energy consumption monitoring platform of a training equipment. The platform adopts advanced cloud platform technology. It organically combines cloud computing storage with advanced intelligent measurement equipment, data acquisition and transmission equipment and refined management software, which realizes real-time measurement and data transmission, acquisition and storage, data operation and statistical analysis of energy consumption of school training equipment. And it improves the level of campus energy management, it lays a foundation for further building the campus energy consumption detection system.

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