Design and Research of Intelligent Building Control System

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Abstract. This paper designs and studies an intelligent building control system. The use of object-oriented design principles to design a building automatic control system is an inevitable product of scientific development, a result of the application of modern scientific and technological achievements, and is based on the development of building fieldbus technology. The advantages of the intelligent building control system include: easy design, easy construction, easy to use, easy to manage, and easy to maintain. Through the design and implementation of intelligent building control systems, energy efficiency can be improved, property management efficiency can be improved, technology application thresholds can be reduced, big data value-added services can be added, and energy control can be fully automated and unattended.

1. Introduction

With the development of urbanization, the construction of smart buildings has become an important part of modern urbanization. The electrical equipment in buildings continues to increase and the consumption of electrical energy increases. In addition, the current control of building electrical equipment is generally based on human control. The traditional energy-saving system has the disadvantages of complex wiring, high cost and difficult to maintain. Intelligent building energy saving is an important part of smart building construction, so it is necessary to study to reduce buildings Technology related to energy consumption.

Combining the Internet of Things technology with the intelligent building energy consumption monitoring system is an inevitable trend in the development of modern intelligent buildings. This trend has promoted the promotion and application of indoor energy consumption monitoring systems. On the other hand, thanks to the huge demand for modernization of buildings, the results of research and development of Internet of Things technology have been practiced and tested. The intelligent building energy-saving system based on the Internet of Things can monitor the internal environment of the building in real time, monitor energy consumption, realize the optimal configuration and reasonable use of electrical energy, ensure the reliability of the work of electrical equipment, and improve the utilization rate of energy. At the same time, the development of intelligent building energy-saving systems based on the Internet of Things will be a qualitative improvement for people's modern low-carbon environmental protection life, raising people's energy-saving awareness, and at the same time, promoting the development of renewable energy is a potential driver of social and economic development force.
2. Internet Energy Management Cloud System

The Internet energy management cloud system is used to combine energy management technology and engineering product technology to achieve intelligent energy management. Through the analysis of energy monitoring data, energy closed-loop control is realized. The block diagram of the Internet energy management cloud system is shown in Figure 1.

![Figure 1. Block diagram of Internet energy management cloud system.](image)

The intelligent building energy consumption monitoring system is to design and develop a monitoring system platform for the smart meters, smart remote water meters, temperature sensors and other devices installed in it by using computer network technology, distributed computing technology, and data flow technology. Realize the collection and itemized statistical processing of water consumption, electricity consumption, temperature and other data.

The intelligent building energy consumption monitoring system mainly consists of four subsystems: building information interaction, real-time processing of building energy consumption, building energy efficiency pre-alarm and multi-dimensional analysis, and system management subsystem. By deploying its sub-modules in various devices in different locations, such as smart meters, smart gas meters, temperature sensors and so on. Before acting, set up and manage it. After the configuration is completed, the relevant mass energy consumption data required by the host computer can be obtained. Among them, the collection of power information is completed by the power data collection equipment of the power monitoring and energy efficiency management system. The water consumption and energy consumption information collection of the intelligent building construction is completed by configuring the collection unit, and the collected water consumption and other information data are transmitted to the host of the intelligent building energy consumption monitoring system. Real-time collection and monitoring of building energy consumption.

The energy management cloud system provides energy operation data for energy experts and energy conservation managers. Energy experts use cloud data for data mining, energy conservation analysis, energy consumption evaluation, energy consumption diagnosis, energy transformation and energy optimization management services. ORACLE database is used to support data storage and management of 5000 building energy-saving projects. Energy management cloud data provides management functions such as energy real-time data storage, data classification statistics and query, and provides convenient Internet management tools for energy experts and managers. The smart energy management system is shown in Figure 2.
Figure 2. Diagram of smart energy management system.

The intelligent building energy consumption monitoring system can connect the collection terminals, such as smart electric meters and smart remote water meters. The collected energy consumption data is sent to the data terminal for statistical analysis. The collection terminal can classify and measure the same kind of energy consumption according to different uses. In this way, itemized measurement and classified measurement of energy consumption data are realized. The communication method between the intelligent building acquisition terminal and the collector can be wired or wireless: the main wired methods are CAN and RS485; the wireless methods are GPRS, ZigBee, GSM, Bluetooth, etc. According to the actual application scenario, the communication method combining wired and wireless is finally selected.

3. Analysis of building energy efficiency management

According to relevant statistics, the energy consumption of air-conditioning, lighting, elevators and other systems in commercial buildings such as office buildings and hotels is roughly as follows: ① Air-conditioning: The proportion of air-conditioning energy consumption in office buildings accounts for 60% of the total energy consumption, and the lower limit is 50%, the upper limit Not higher than 70%; hotel HVAC (heat, ventilation and air conditioning control) energy consumption accounts for 44% of the total energy consumption. ② Lighting: the energy consumption of office lighting accounts for 23% -55% of the total energy consumption, with an average of 26%; the energy consumption of hotel lighting accounts for 29% of the total energy consumption. ③ Elevator: The energy consumption of office buildings and office buildings accounts for 8% of the total energy consumption, and the energy consumption of hotel elevators accounts for 10% of the total energy consumption.

Building energy allocation: air conditioners consume more than 50% of electricity. There are five types of fluid machinery in the central air-conditioning system-terminal fan, chilled water pump, refrigeration unit compressor, cooling water pump and cooling tower fan. They are fluid conveying equipment, driving the five fluid circulations in the system to ensure the air conditioning refrigeration process Continued. These fluid machines are the main energy-consuming equipment of the central air-conditioning system.

Among the energy-consuming equipment of the central air-conditioning system: the energy consumption of refrigeration equipment such as refrigerators accounts for about 40% to 45% of the total energy consumption of the system; the energy consumption of pumps and other transportation
equipment accounts for about 20% of the total energy consumption of the system; The energy consumption of cold equipment accounts for about 35% to 40% of the total energy consumption of the system. Peak and valley time-of-use electricity price standards (Beijing) are shown in Table 1.

Table 1. Peak and valley time-of-use electricity price standards (Beijing)

| Name     | Peak price       | Flat price       | Valley price     |
|----------|------------------|------------------|------------------|
| Period   | 10:00-15:00      | 18:00-21:00      | 7:00-10:00       |
|          | 15:00-18:00      | 21:00-23:00      | 23:00-The next   |
|          |                  |                  | day 7:00         |
| Unit     | (Yuan / kwh)     | (Yuan / kwh)     | (Yuan / kwh)     |
| Amount   | 1.3782           | 0.8595           | 0.3658           |
| Januy to June, September to December (total 10 months) |

It can be seen from the table that avoiding peak-end power consumption is the key to building energy conservation, and corresponding building energy conservation measures need to be formulated. For example: increase the outlet temperature of the refrigeration unit; appropriately relax the control requirements for the lobby, corridors, and offices, and increase the set temperature; under the premise of ensuring comfort, such as the entrance of the gate, the temperature can be set to 28 ~ 30℃, 4 ~ 4 lower than outdoor 5℃; corridor set at 27 ~ 28℃ has met the requirements; office set at 26℃ is also very comfortable. According to seasonal changes, adjust the amount of fresh air reasonably. According to hygiene requirements, everyone in the building must ensure a certain amount of fresh air. But too much fresh air volume will increase the energy consumption of fresh air. Taking hotels in Shanghai as an example, under the design conditions (outdoor temperature in summer 26℃, relative temperature 60%, winter room temperature 22℃, relative humidity 55%), it takes 6.5kWh of cooling capacity and 12.7kWh of heat to handle one kilogram of outdoor fresh air. Therefore, under the premise of meeting the requirements of indoor hygiene, reducing the amount of fresh air has a significant energy saving effect.

The best equipment start and stop time control, peak elimination and valley filling. Night purification: In summer, outdoor low-temperature fresh air is introduced to replace indoor turbid air. Improve air quality and save energy. Shorten the unnecessary start and stop tolerance time of air conditioners. During pre-cooling and pre-heating, closing the outdoor fresh air valve can not only reduce the equipment capacity, but also reduce the energy consumption of cooling or heating caused by obtaining fresh air. Public lighting: timing control, illuminance control, grouping light control, grouping control of underground parking spaces, lane timing, motion detection and lighting.

Peak avoidance operation. In areas where a variety of electricity prices are implemented, the building automatic control system can be used to coordinate with ice storage equipment and emergency generators to remove some relatively unimportant electromechanical equipment to reduce peak load during peak electricity consumption, or put into emergency Measures such as generators and the release of stored cooling capacity are used to avoid peak operation and reduce operating costs.

4. Operation analysis of a subway line
The monitoring objects of the energy-saving system of a subway line are combined air conditioner blower, return fan, fresh fan, electric air valve (fresh air, supply air, return air, exhaust air),
temperature and humidity sensors (fresh air, supply air, return air), Indoor temperature and humidity sensor, CO2 sensor. Chiller, chilled water pump, cooling water pump, cooling tower, flow switch, electric water valve, differential pressure bypass valve, chilled water supply and return temperature, cooling water supply and return temperature, outdoor temperature and humidity. The energy-saving system system structure is shown in Figure 3.

**Figure 3.** Energy-saving system system configuration diagram.

The main functions of the energy-saving system include the energy-saving system and the original system control mode; setting the indoor temperature as a control point for the air-conditioning unit blower and return fan with the same frequency conversion operation; setting the outlet temperature as the control of the dynamic balance valve to adjust the flow Point; set the CO2 concentration value as a control point for the start and stop of the new fan; controlled by dual parameters of CO2 concentration and indoor temperature.

Automatically select the number of chillers put into use according to the load, and automatically load and reduce the load (the number of operating units is selected according to the principle of the highest comprehensive energy efficiency ratio, which needs to be calculated and set according to the partial load curve of the chiller and the pump power consumption curve). According to the difference between the temperature of the cooling water supply and return water and the difference of the supply and return water pressure of the remote air conditioning unit, the frequency control operation of the cooling water pump is controlled. According to the outdoor temperature and humidity, the optimal setting value of the cooling water temperature is selected, and the return water temperature of the cooling water is used to control the cooling tower fan level adjustment or the number of units used.

The system control methods mainly include:

1. Energy saving by frequency conversion speed regulation
   Automatically adjust the motor frequency according to the load, improve equipment utilization, reduce power consumption and achieve efficient operation.

2. Soft start energy saving
   When the AC motor starts directly, the starting current is 6 ~ 10 times of the trial running current, and after using the soft start technology, the starting current is reduced to 1 ~ 3 times.

3. Temperature control
   The temperature (or temperature difference) signal is used as the feedback signal, and the constant temperature (difference) control is used as the target signal.

4. Automatic control
The automatic control of ventilation and air conditioning includes operation control, protection control, energy saving control, etc., and the PID can be adjusted by setting the temperature as required, so that the output power of the motor changes with the change of the thermal load.

5. Conclusion
The intelligent building control system establishes an energy adaptive control model think tank through artificial intelligence energy management, automatically calculates the energy online effective load, calculates the load that can be switched, and realizes energy control adaptive intelligent control. Through the study of the operation rules of energy big data, calculate the law of terminal load change with load, realize energy prediction control, and realize the balance of energy production and demand.

Through the design and implementation of intelligent building control systems, energy efficiency can be improved, property management efficiency can be improved, technology application thresholds can be reduced, big data value-added services can be added, and energy control can be fully automated and unattended.

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