

# Study on Energy Saving Control of Electrical System in Office Building

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**Aims:** To design energy-saving control system of electrical system in office buildings; **Methods:** discusses the structure and function of electric control system of construction equipment, and points out the energy saving mode of the electrical automation control system of construction equipment. Finally, applies the above theory to the design of energy saving control system in X company's office center electrical system; **Results:** The design of the electrical energy control system for the X company office center to save about 20% of the cost; **Conclusions:** The design of the electric energy saving control system has obvious energy-saving effect, and has important value of application popularized.

## 1. Introduction

With the development of economy and the progress of science and technology, ordinary building can no longer meet the needs of people. The advent of the information age has brought the new development direction of architecture, and intelligent building came into being (Ghaffarianhoseini et al., 2016). Intelligent buildings and general construction has a significant difference, not only to meet people's living environment, safety and comfort of the general requirements, but also to strengthen the operational efficiency of buildings and has obvious energy saving effect, to achieve building electrical equipment of the automatic control, more in line with modern building development concept (Veps and Inen, 2014).

Building operation energy saving is the key to promote energy saving building development. Building equipment electrical automation system is the control core of intelligent building, it is the key to realize intelligent station automation, energy saving and comfort. The electrical automation system of construction equipment is quite complicated. It is formed by the integration of many sub-systems. The number of subsystems is different and the operation mode is different (Wang et al., 2014). To intelligent building research, the key lies in its equipment system. In addition, the current energy situation in the world is becoming more and more serious. Energy saving has become a worldwide concern. Electric automatic control system can effectively reduce building energy consumption and save energy (Brencis et al., 2017). Therefore, it is of great practical significance to strengthen the research of electrical equipment automation system.

## 2. Method

### 2.1 Design and construction of electrical automation system for building equipment

#### (1) Outline of Electrical Automation System for Construction Equipment

Building equipment control system involves many subsystems; its coverage is more extensive. Air conditioning monitoring system which is the largest energy-saving space and it is the focus of this study system.

The building equipment automatic control system can realize the automatic control to the electrical equipment inside the building, utilize the advanced control and communication technology to interconnect the systems, and utilize the management system to integrate so that the equipment can play the advantages and potential of the whole.

#### (2) The Control Function of Electrical Automation System for Building Equipment

The air conditioning unit automatic adjustment uses the DDC controller to realize the system the control function, installs the temperature sensor in the return air pipe of the air conditioning unit, it carries on the examination to the temperature also transmits to the DDC to compare with the prearranged temperature. In the control of the use of proportional integral and differential calculation, so the output voltage signal can also be achieved at the same time on the electric control valve automatic control.

The central station uses Windows NT as the operating platform, the application software for the industry standard, and has a distributed control system, using two level mixed network structures, in the system running status monitoring, mainly used in the whole culture and graphical user interface.

#### (3) The composition of the system hardware

The construction of electrical control system of the network structure is divided into two level network structures, which belongs to a class of high-speed LAN; realize its function in general is carried out by a workstation, controller and file server etc. the two level is the main line of on-site control, through the controller, air conditioning, lighting and other related equipment to achieve its function. In addition, the second level network uses the first level network to achieve two-way communication, so that network information is passed.

#### (4) Software Function of Electrical Automation for Building Equipment

The electrical automation software for building equipment includes controller software, workstations and portable workstations, and application software.

The controller software is mainly controller internal operating system, which has the function of system operation, communication and controller function. Workstation consists of two parts: database and operating system. The software is supplied by CD-ROM, mostly commercial software. Portable workstations mainly for the operating system software, the function is not stronger than workstation, generally need to use the relevant communication software to control or programming the controller. Application software users can program their own, its programming language is similar to natural language, decreased the professional requirements of programmers, and can meet the process description, report definition, logical judgment and alarm system and other system functions.

## **2.2 Energy - saving control mode of electrical automation system for building equipment**

### (1) Energy - saving automation control of air conditioning

Air conditioning and refrigeration station-related equipment is the most energy-consuming of the central air-conditioning system, through the use of the BAS terminal load calculation to adjust the working hours of the unit and the output of hot and cold air volume, so as to achieve the optimal operation of the unit. With the rapid development of scientific technology in modern society and the growing popularity of the Internet, the central air conditioning units and refrigeration equipment manufacturers related to the use of computer technology realized the digital element control of relevant equipment, for the realization of automatic control provides a good equipment foundation.

### (2) Electric Automation Control Mode of Variable Flow System

In order to ensure the premise of comfort as much as possible to save energy consumption, variable flow system came into being. Variable flow system is divided into variable air volume system, variable water volume system and variable refrigerant flow system (Veps and Inen, 2014).

VAV system is the key to the completion the principle of VAV air supply terminal equipment, especially the terminal equipment and the entire VAV air conditioning system comes with control equipment. VAV system is mainly divided into AHU-VAV system and FCU-VAV system, AHU-VAV system air conditioning system duct air supply is fixed, through the adjustment of air volume to control the load changes in the room; the FCU-VAV is the use of indoor FCU plus step less variable power controller to control the FCU heat exchange rate, and fixed its cold water to control the indoor load changes.

Variable water system through a certain water supply temperature to enhance the effectiveness of the heat source machine, and through a professional way to achieve water pump energy saving pump energy consumption. The energy saving effect of variable water quantity system mainly depends on the application ratio of variable water quantity system and the control of water pump.

The structure of the variable refrigerant system is similar to that of the split type air conditioner, and corresponds to a set of indoor units through an outdoor unit. The use of frequency control technology through open the room machine to control the compressor speed of the outside machine, to achieve control of refrigerant flow.

### (3) Electrical Automation Control Mode of Air - conditioning Fan - coil

Air-conditioning fan to occupy the entire air-conditioning system energy consumption of about 50%, using VAV system technology scientific control the fan's working hours can achieve the purpose of saving energy, central air conditioning terminal fan coil is mainly through the following means to control: Adjust the temperature inside the public area settings, in the high temperature season from the outside to inside reduce the

temperature the office building setting value; set the temperature at night, decrease the indoor temperature control value, reduce energy consumption; the implementation of natural cooling, under appropriate conditions, use outdoor fresh air to reduce air-conditioning load; use of remote temperature control equipment, monitoring the temperature difference between office buildings and set the temperature to achieve automatic control of two-raft and fan speed.

### 3. Results

X company office is mainly composed of six buildings, the electrical equipment automation control system of the project as a result of X company office center of the difference between the different functional design. X office center is divided into two parts: ground and underground, the underground part is divided into parking lots and equipment rooms, the ground part is mainly for six office buildings.

#### 3.1 Design of electrical automation control system of X company's office center

In X office automation control of the first task is to ensure that the premise of building comfort, as far as possible to achieve energy conservation control. In this project, a series of advanced energy-saving measures such as air-conditioning zone control, group control of refrigerating units, temperature / humidity control of air conditioning, and equipment life-balance control are adopted to realize energy saving and reduce post-operation cost. In order to ensure the reliability of electrical equipment automation system, the control and inspection points in the system are accessed by DDC controller. The monitoring station and the monitoring target do not establish a direct input / output relationship, and ensure the live real-time control functions are programmed in the DDC controller. In the project is mainly air conditioning units and other equipment need to carry out closed-loop control, to apply the specified PID closed-loop control, PID closed-loop control adjustment diagram is shown in Figure 1.

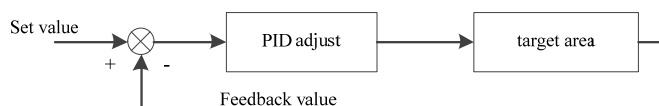


Figure 1: PID closed-loop control adjustment control block diagram

#### (1) Refrigeration station control

Refrigeration station equipment control objects as shown in Table 1.

Table 1: PID refrigeration station control object table

Control object	Explanation
Chillers	Unit start, stop control, fault, run, manual / automatic condition control
Cold water pump	Pump on, stop control, fault, run, manual / automatic condition control
Water flow switch	Control the flow of water
Cooling tower fan	Fan start, stop control, fault, run, manual / automatic condition control
Cooling tower inlet valve	Water inlet valve control
Supply/return water temperature	Monitoring and control of cooling water supply water temperature and backwater temperature
Supply/return water pressure	Monitoring and control of cooling water supply pressure and backwater pressure
Chilled water pressure adjustment	Adjustment and Control of Chilled Water Differential Pressure
Cooling water flow	Cooling water flow monitoring
Expansion tank	Liquid level monitoring and control in water tank

Cooling machine system unit monitoring and other related cooling water system monitoring equipment are the main contents of the chiller system monitoring. Cold water system monitoring process is shown in Figure 2.

The inlet / return water total pipeline configuration pressure sensor to carry on the calculation of the pressure difference between the inlet return water, analysis and judgment the pressure difference and the set value, and then use the PI way to control the valve, control the differential pressure in the allowable range, when the cold water system is closed, the bypass valve is all in the closed state, as shown in Figure 3.

Water tank monitoring and control including monitoring and control tank level position, when the liquid level is too low or too high, it sends out alarm information and records the running state of the water tank.

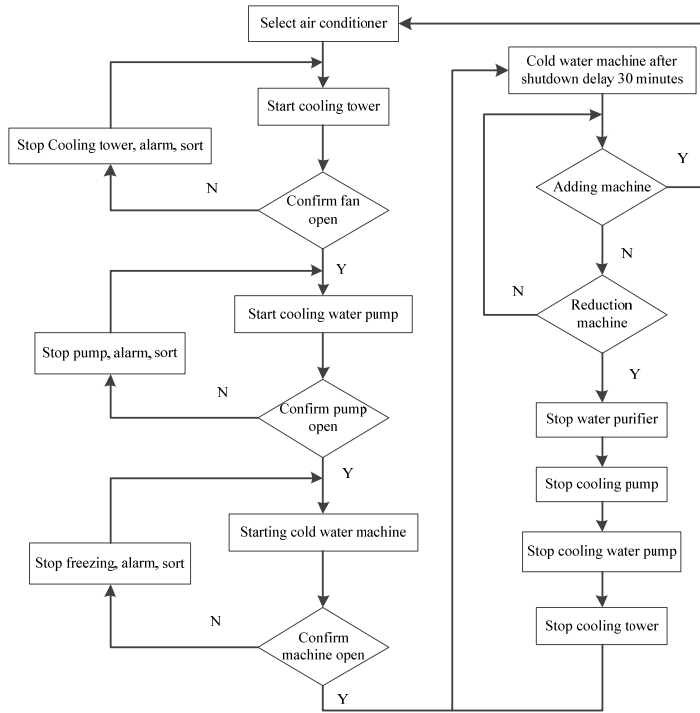


Figure 2: Chilled water system monitoring flow chart

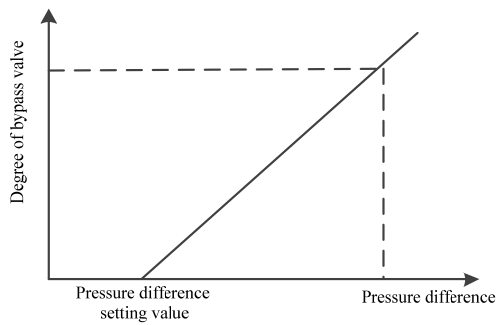


Figure 3: Differential pressures bypasses monitoring

(2) Air conditioning control of air handling units  
 Schematic of the fresh air units is shown in Figure 4.

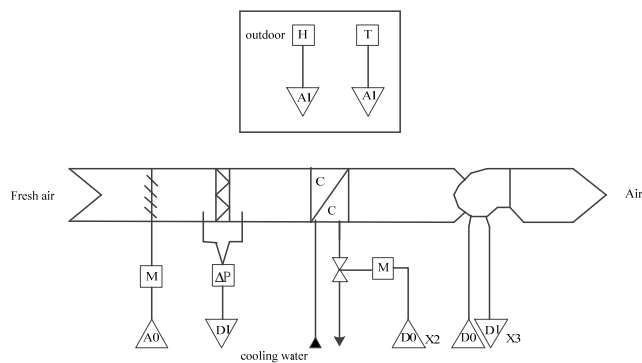


Figure 4: Schematic diagrams of fresh air units

It is possible to realize the difference between the return air temperature and the set temperature, using PID to adjust the hot water valve and cold water valve to open the surface to achieve the supply air temperature control; once the return air temperature to adjust the water valve to open the surface is increased, the valve opening side of the regulating valve is reduced when the temperature is lowered; to achieve differential pressure monitoring filter and remind the user to clean the filter for maintenance.

### (3) Exhaust system

The main monitoring and control function of the exhaust system is the operation of the fan and its open / close control, overload alarm, and can record the fan running time, the central station can display and record the above parameters, export or print.

### (4) Water supply and drainage system

The main monitoring and control of water supply and drainage system to monitor the pump operation, failure and its manual, automatic; pump on or off; the liquid level height of puddles, living water tank, fire water tank, When the liquid level is too low when the drainage pump stops working, when the liquid level is too high, it gives a real-time alarm, and use drainage pumps to get rid of the water.

### (5) Power Distribution System Monitoring

In order to expand energy-saving effect as much as possible, we have strengthened the control and management of electricity, in the automation control system to increase the power monitoring and management functions, the power monitoring system framework is shown in Figure 5:

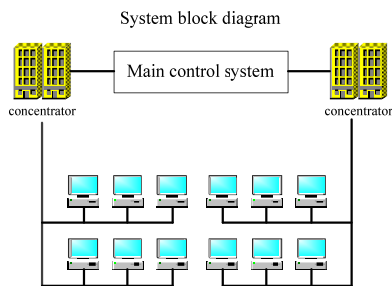


Figure 5: Electricity monitoring system frames

When the master station issues an instruction to the concentrator, concentrator through the corresponding analysis make the corresponding treatment, such as reading data, real-time monitoring. Using the power line carrier transmission instructions to the terminal device, collect the relevant data and then transmitted to the construction equipment electrical automation control system. The concentrator has the core chip, which can process the data and carry on the data communication, at the same time, receive the terminal receipt and issue the control command.

## 3.2 Integration of electrical automation control system for building equipment

Building equipment electrical automation control system integration is the core work to achieve management, because X company office center buildings are more decentralized and complex functional partition, automatic control system has many subsystems, to achieve coordinated operation of various types of systems is the key to the project, it directly affects the X company's office environment, environmental control and energy-saving effect, and it has an important bearing on management efficiency, future operating costs and operational safety. This project automatic control system integration is uses the EBI integration system, upper communication network is based on TCP / IP protocol Ethernet, through this network link the office central Local Area Network (LAN). The backbone of the control network consists of a control network that links the EBI station, the regional network manager and its DDC digital controller.

## 3.3 Management software

The system adopts the open structure, server using WindowsNT operating system, operators are mostly more familiar with Windows system interface, and has some operational capability, reducing the technical staff training expenses. The system architecture based on Ethernet using TCP / IP protocol. The information management system to obtain data can use DDE, OPC and ODBC and other means, and simultaneously support BACnet and its LonMark standard equipment protocol.

### 3.4 The control effect of X company's office center electrical system energy saving

By calculating the operating costs of X center run per square meter per year for 1200~1600 RMB, its cost structure is roughly: Fixed cost is 73.22%; energy costs are 9.11%; maintenance cost is 10.85%; cleaning cost is 6.82%, the effect is obvious after using BAS energy-saving, only the air unit system can save 170,358 RMB funds, as shown in Table 2.

Table 2: Energy Saving Effect of Air Unit System

Serial number	Name	Annual energy saving (kWh)	Annual energy-saving funds (RMB)
1	Cold water pump	13469	9428
2	Cooling water pumps and fans	32138	22496
3	Air compressor cooling system	197763	138434
Total		243370	170358

It is estimated that the electrical equipment automation system can be X office center about 20% energy saving, energy-saving effect is obvious, and also have a larger space for optimization.

## 4. Discussion

In this paper, the relevant control technology and model of electrical equipment automation control system are studied, such as variable flow technology, power supply and distribution system optimization mode, and then on this basis we proposed office center for energy-saving control mode. Finally, according to the characteristics and requirements of X Company office, the proposed energy-saving mode is put into practical application, through the HVAC, ventilation and power distribution and other aspects of optimal control, in order to achieve the purpose of saving energy. Through the EBI system integration, X company office center equipment, electrical automatic control system for system integration, so as to unified management and control. After calculation, construction equipment, electrical automation system for the X office center energy saving about 20%, energy-saving effect is obvious.

## 5. Conclusion

In this paper, firstly, we expounded the background and current situation of the electrical control system of building equipment, further explored the structure and function of electric control system of building equipment, and analyzed the energy saving mode of electric control system of building equipment, finally, the above theory is applied to the headquarters office of X Company, and further research on how to construct the electrical automation and energy-saving control system of building equipment. This study is suitable for the office building automation energy saving control system, and it has certain theoretical significance and practical value.

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