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IMPROVING ENERGY EFFICIENCY IN ADMINISTRATIVE BUILDINGS THROUGH INTELLIGENT CONTROL OF ENGINEERING SYSTEMS BASED ON BMS TECHNOLOGIES

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Abstract

This thesis examines the issues of improving energy efficiency in administrative buildings through the intelligent control of engineering systems based on BMS technologies. The study analyzes the technical and operational significance of coordinating heating, ventilation, air conditioning, lighting, power supply, and energy monitoring systems through a unified digital control platform. The BMS system enables real-time monitoring of energy consumption in a building, automatic regulation of engineering equipment operating modes, identification of excessive energy consumption, and reduction of inefficient operating modes associated with the human factor. The analysis results show that the implementation of BMS technologies is important for optimizing energy consumption in administrative buildings, reducing operating costs, ensuring indoor microclimate stability, and bringing the building closer to the modern smart building concept.

Keywords: BMS, administrative building, energy efficiency, smart building, HVAC, intelligent control, energy monitoring, automation, engineering systems, energy management.

Introduction

Today, reducing energy consumption in buildings and effectively managing engineering systems are considered among the important directions of sustainable development worldwide. Administrative buildings, in particular, are among the facilities with high energy consumption because they continuously use electricity,

thermal energy, cooling, ventilation, and lighting systems. In such buildings, energy consumption often depends not only on the power of the equipment, but also on the operating mode and the control algorithm under which the equipment functions.

In traditional control systems, heating, ventilation, air conditioning, and lighting systems are often controlled separately. This situation leads to a lack of coordination among engineering systems, increased energy consumption, and more complicated operational supervision. For example, the unbalanced simultaneous operation of air conditioning and heating systems, the continued operation of lighting or ventilation in unoccupied rooms, and the continuous operation of equipment without considering outdoor environmental conditions cause excessive energy consumption.

From this point of view, Building Management System (BMS) technologies represent a modern and promising direction for improving energy efficiency in administrative buildings. BMS is an automated control system that enables the main engineering systems of a building to be monitored, controlled, and optimized through a unified digital platform. Through sensors, controllers, actuators, a dispatcher interface, and data analysis modules, this system monitors energy consumption in the building in real time and automatically forms the required operating modes.

The purpose of this thesis is to substantiate the scientific, technical, and operational significance of improving energy efficiency in administrative buildings through the intelligent control of engineering systems based on BMS technologies.

Research Methodology

In the study, the main factors affecting the energy consumption of engineering systems in administrative buildings were analyzed based on a systematic approach. The main attention was focused on the possibilities of interconnected management of HVAC, lighting, ventilation, power supply, and energy monitoring systems through the BMS platform.

The methodological approach includes the following stages: analysis of the structure of the main energy consumers in an administrative building; assessment of the energy consumption of HVAC, lighting, and ventilation systems under traditional control modes; substantiation of the possibilities of automatic and scenario-based control of engineering equipment through a BMS system; analysis of the approach to forming optimal operating modes based on sensors, controllers, and energy monitoring data; and definition of criteria for evaluating energy savings, operational convenience, and indoor microclimate stability after BMS implementation.

As a result of implementing BMS technologies, energy savings can generally be assessed using the following expression:

$$E_{saving} = E_{\beta e} f_{ore} - E_a f_{ter}$$

where: E_{saving} is the amount of saved energy; $E_{\beta e} f_{ore}$ is the energy consumption before BMS implementation; $E_a f_{ter}$ is the energy consumption after BMS implementation.

The relative efficiency of the BMS system can be determined using the following expression:

$$\eta^{BMs} = (E_{saving} / E_{\beta e} f_{ore}) \cdot 100\%$$

where: η^{BMs} is the energy-saving efficiency achieved through the BMS system, %. These expressions make it possible to assess the impact of a BMS-based control system on energy efficiency from a general methodological point of view without disclosing specific facility data.

Main Part

In administrative buildings, energy consumption is formed through several main engineering systems. These include heating, ventilation and air conditioning systems, lighting devices, pumps, power supply equipment, server and office equipment, security systems, and dispatcher systems. When these systems operate separately, their modes may not be coordinated with each other. BMS integrates these systems into a

unified digital environment and transforms energy consumption into a manageable and analyzable process.

One of the most important functions of a BMS system is the optimal control of HVAC systems. In administrative buildings, HVAC systems usually account for the largest share of energy consumption. If heating, cooling, and ventilation systems are not controlled according to indoor temperature, humidity, air quality, and occupancy, excessive energy consumption occurs. Through temperature sensors, humidity sensors, CO_2 sensors, and occupancy-detection devices, BMS automatically regulates the operating mode of HVAC systems. As a result, energy consumption is reduced while maintaining a comfortable indoor microclimate.

Lighting system control is also an important part of BMS technologies. In traditional administrative buildings, lighting is often controlled manually by staff, and luminaires may remain on outside working hours. BMS can automatically control lighting based on natural light levels, working hours, room occupancy, and predefined scenarios. For example, when daylight is sufficient, the power of artificial lighting is reduced; when no one is present in the room, lighting is automatically switched off or transferred to a minimum mode.

Energy monitoring defines the analytical capabilities of the BMS system. By monitoring the consumption of electricity, thermal energy, and other resources in real time, building administration can analyze the energy consumption profile. This allows excessive consumption points to be identified, abnormal changes in energy use to be monitored, and operational decisions to be made on the basis of evidence.

The BMS system is not only an energy-saving tool, but also a platform that increases operational reliability. It monitors the operating status of equipment, records alarm signals, indicates the need for maintenance in advance, and facilitates the work of engineering services. Such an approach creates the possibility of moving from reactive repair to predictive maintenance.

Another important aspect of BMS technologies is the reduction of the impact of the human factor. In manually controlled systems, energy savings often depend on staff discipline. BMS automates control algorithms and ensures stable implementation of the established energy-efficiency policy. This brings energy management in administrative buildings closer to the principles of ISO 50001.

Results and Discussion

The analysis results show that the implementation of BMS technologies in administrative buildings has a comprehensive impact on energy efficiency. First, the operating mode of HVAC systems is adapted to actual demand. Second, the lighting system is controlled according to natural light and occupancy. Third, excessive consumption and inappropriate operating modes are identified through energy monitoring. Fourth, the technical condition of engineering systems is continuously monitored.

The main engineering systems controlled through BMS and the expected energy effects are summarized below.

System controlled through BMS	Problem in the traditional state	BMS-based solution	Expected result
HVAC system	Imbalance between heating and cooling modes	Automatic control based on temperature, humidity, and CO_2 sensors	Energy consumption decreases, and the microclimate stabilizes
Lighting system	Lighting continues in unoccupied rooms	Control through motion, occupancy, and natural light sensors	Excess electricity consumption decreases
Ventilation	Operation in a constant or incorrect	Ventilation adjusted to air quality and	Air exchange is optimized

System controlled through BMS	Problem in the traditional state	BMS-based solution	Expected result
	mode	number of occupants	
Energy monitoring	Consumption profile is not fully visible	Real-time data collection and analysis	Excess consumption points are identified
Alarm signaling	Faults are detected late	Automatic warning and dispatcher control	Operational reliability increases
Maintenance	Scheduled or reactive repair	Data-based predictive maintenance	Repair costs are optimized

The table shows that the BMS system affects each engineering system in the building not separately, but in an interconnected manner. Therefore, energy efficiency is achieved not by reducing the capacity of a single device, but by intelligently controlling the operating mode of the entire building.

The discussion results show that three main effects can be distinguished in the implementation of BMS technologies in administrative buildings. The first effect is the energy effect, which is formed by reducing excessive energy consumption and adapting engineering systems to actual demand. The second effect is the operational effect, which is associated with monitoring the operating status of equipment, early detection of faults, and proper organization of maintenance. The third effect is the social and environmental effect, which is manifested in creating a comfortable microclimate for employees, rational use of resources, and improving the culture of building operation.

In this regard, BMS technologies transform administrative buildings from

ordinary energy-consuming facilities into data-driven, controllable, and energy-efficient smart building systems.

Conclusion

Intelligent control of engineering systems in administrative buildings based on BMS technologies is a modern and comprehensive solution for improving energy efficiency. The BMS system integrates the main engineering systems, such as HVAC, lighting, ventilation, energy monitoring, and alarm signaling, into a single digital platform and enables their operating modes to be monitored and optimized in real time.

The analysis results show that the implementation of BMS makes it possible to reduce excessive energy consumption in a building, optimize operational costs, ensure indoor microclimate stability, and increase the reliability of engineering systems. In this case, energy efficiency is achieved not only by replacing equipment, but by the intelligent organization of control algorithms.

Thus, BMS technologies are an important engineering solution that brings administrative buildings closer to the modern smart building concept, improves the quality of energy management, and ensures sustainable operation. This approach is important for the rational use of energy resources, reducing operational risks, and ensuring the environmental sustainability of buildings.

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