# Research on the Development of Building Energy Efficiency Management Platform for Colleges Based on BIM Technology in the Context of Carbon Neutrality

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**Abstract.** In the context of the national promotion of the construction of a conservation-oriented society, it is particularly urgent to promote energy conservation in colleges and universities and build a conservation-oriented campus. This paper focuses on the development path of a building energy management platform for university campuses based on BIM technology, aiming to achieve safe, reasonable and scientific energy use in university campuses and to promote the further application and development of BIM technology in the operation and maintenance phase.

**Keywords:** double carbon; BIM; green campus:energy consumption management

## 1 Introduction

With the rapid development of global society and economy, the problems of energy and carbon emission are becoming more and more prominent. China has put forward the goal of "double carbon", and the building sector is an area with great potential for energy saving[1]. With the policy, financial and technical support, the development of green buildings in China has made remarkable progress. Colleges and universities as a densely populated, multi-functional area, its energy consumption is particularly prominent, it is 4.4% of the national population consumes about 8% of the social energy[2], which indicates that the college campus has a huge potential for energy saving. At present, there are fewer studies on campus energy consumption management in China, and after the completion of some energy consumption platforms, they only do basic usage statistics for energy consumption, lack of collation and in-depth excavation of data, and do not play the role of in-depth analysis, making it difficult to help the further development of energy conservation management. This study aims to combine BIM tools with database technology to help campus research build a more efficient and intelligent building energy management platform.


Q. Gao et al. (eds.), *Proceedings of the 2024 7th International Conference on Structural Engineering and Industrial Architecture (ICSEIA 2024)*, Atlantis Highlights in Engineering 30,
https://doi.org/10.2991/978-94-6463-429-7_25

# 2 BIM technology and energy management

## 2.1 Application of BIM technology in China

Building Information Modelling (BIM) technology is an information integration system for the whole life cycle of construction projects, which promotes collaborative work at all stages through visual simulation and promotes the development of information technology in the construction industry. In China, BIM technology has been gradually popularised from the design to the construction stage, solving problems such as pipeline conflicts and light simulation. However, the construction and operation and maintenance phases face greater challenges, as they involve multi-party collaboration and complex management.

To promote the application of BIM, the Ministry of Housing and Urban-Rural Development (MOHURD) has issued a plan that emphasises full life cycle integration and digital collaboration[3] . However, in reality, some projects simply apply BIM for remote control and data collection, without realising its potential[4].

## 2.2 Energy consumption management based on BIM technology

The energy management with BIM technology focuses on the energy consumption of water, electricity, gas and coal in the daily operation of a building, aiming at optimising the allocation of energy consumption and improving energy efficiency[5]. The building energy management platform takes BIM technology as the core, combines with the Internet of Things, cloud computing and big data to build an intelligent energy management system. The platform uses BIM to establish a three-dimensional model to ensure accurate and complete information. IoT achieves real-time data collection and monitoring, and cloud computing and big data carry out data integration, analysis and processing to generate dynamic diagrams of energy consumption, providing managers with an intuitive and comprehensive view of energy consumption. This helps to formulate scientific energy-saving plans, improve management efficiency, reduce energy waste, and achieve green and sustainable O&M management.The necessity of energy consumption management in college

# 3 The necessity of energy consumption management in college

College campuses face the problem of high energy consumption and regulatory difficulties in operation and maintenance due to dense population and diverse building functions. Currently, campus energy supervision measures are insufficient, ignoring differences in buildings, functional areas and the nature of energy use, resulting in low energy efficiency and serious waste. For this reason, many domestic schools began to use the energy management system, such as Zhejiang University, Ningxia University and so on. According to the statistics published by the schools, has built campus energy consumption monitoring system of colleges and universities, compared with the average

electricity consumption of general colleges and universities per unit of the building reduced by 67 per cent, can be found in China's colleges and universities have great potential for energy saving. Technology development is rapidly changing, but the supervision system of each school has not been updated for a long time, and the processing and analysis of data is still very superficial, so the development of a more scientific and reasonable energy management platform is very necessary. In order to solve these problems, we use BIM, Internet+, Internet of Things and other advanced technologies on the basis of the campus basic information resource sharing platform to achieve the management of the operating status of the equipment, with a view to achieving more efficient energy saving and emission reduction in buildings.

# 4 Design of Energy Consumption Management Platform Based on BIM Technology

## 4.1 Analysis of Functional Requirements

The campus has a variety of buildings with different energy consumption patterns. College buildings have overlapping functions and equipment management and control challenges. In order to manage energy consumption more effectively, we need more detailed and comprehensive statistics, including but not limited to unit area and per capita energy consumption, such as distinguishing between various types of energy use. Take water consumption data as an example: we can separately count the amount of tap water and recycled water, and compare the two, and at the same time, we can also express the use of each period of time in charts, formulate a reasonable range of fluctuations, and make a feedback report on the use of more than a reasonable range, which not only accurately reflects the results of energy saving, but also enhances the effect of energy saving. The platform not only records the energy consumption and characteristics of each building, but also assesses the energy-saving potential of each area, puts forward energy-saving suggestions, and formulates energy-saving plans[6], so that it can truly monitor, manage and control in one, and truly realise the purpose of energy saving and emission reduction. Not only that, the platform should also have visual view and remote control functions to monitor the energy use behaviour of teachers and students, and can consider developing mobile applications to transparently manage and enhance the energy saving awareness of teachers and students. Finally, the platform is a collection of a large amount of data, her interface should be simple and easy to read, to avoid cumbersome, should provide clear navigation and structure, so that users can easily browse and find the content they need, to improve the experience of the administrator, to reduce the burden, so that the monitoring and management is simpler.

## 4.2 Technical requirements

### 4.2.1The model requirements are as follows:

(1) Accurate correspondence: the model must be highly consistent with the physical building to ensure the accuracy of details such as spatial layout and structural construction.

(2) Complete attributes: The attribute information of each component in the model must be exhaustive, including but not limited to material, size and function.

(3) Exhaustive equipment: The model should contain complete equipment information, such as heating, cooling, electrical and other system equipment, to ensure the convenience of subsequent management and maintenance.

(4) Data standardisation: the model data should follow a unified standard and format for data exchange and integration between different systems.

(5) Editability: The model data should be editable to adapt to the updating and modification needs at different stages.

(6) Offline browsing function: the model should support offline browsing to ensure that users can still view and operate the model without network connection.

### 4.2.2 System requirements are as follows:

(1) Ensure compatibility with BIM modelling environment to meet project requirements.

(2) Achieve lightweighting of BIM models to optimise performance and enhance user experience.

(3) Establish a stable and reliable network connection to achieve 24/7 unobstructed network connectivity, including stable connectivity in emergency situations.

(4) Ensure real-time information collection and transmission, data synchronisation and accuracy.

(5) Construct a comprehensive database system, including a BIM model database, a real-time monitoring database and a historical information database to support data management and analysis.

(6) Design user-friendly human-computer interaction interface to provide intuitive and convenient operation experience.

## 4.3 Platform architecture

The centrepiece of this platform is a digital twin built using BIM technology. This means accurately replicating 3D models of campus buildings in the computer and incorporating detailed building component parameters and equipment information. Following this core concept, the author chose the B/S architecture model for development based on specific project requirements. This platform architecture contains a base layer, an intermediate layer and an interface layer[7], as shown in Figure 1. The preservation and updating of system data is rapidly transmitted to the server through the network to ensure that the relevant personnel can grasp the latest information in real time, which greatly improves the efficiency of information transfer and realises the seamless connection and communication among people, buildings and equipment. The platform

takes BIM as the carrier, organically integrates all kinds of information, and ultimately achieves the goal of energy saving and emission reduction through modelling and data analysis.

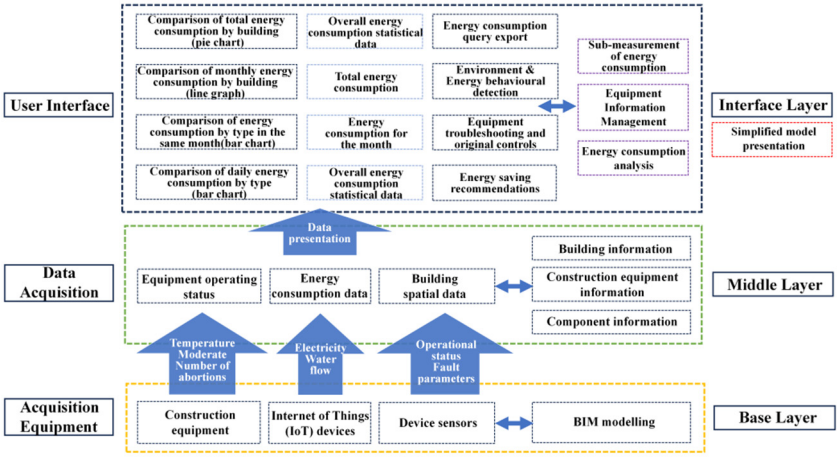


**Fig. 1.** Functional architecture of the platform（Source: Author's own drawing.)

## 5 Function realisation

The 3D model constructed by BIM technology visually displays information and data, combined with energy consumption measurement tools to collect and transmit data to the platform in real time. The system can remotely control and adjust the indoor environment, sense changes in the external environment, and automatically adjust the temperature and humidity to provide a comfortable environment. The energy management module statistically analyses energy consumption and immediately warns of any anomalies. With the improvement of data, the system can collect and analyse data on the environment, user behaviour, etc., to reveal the characteristics of the campus space and potential problems, and support sustainable development[8].

### 5.1 Visualisation

On the computer, we created a digital twin model[9] for each individual building on campus, which shows key information such as the structure of the building and the layout of the equipment in detail. In addition, the model dynamically displays the environmental conditions of each space within the building, including foot traffic, temperature and humidity, as well as real-time energy consumption data. For a more intuitive understanding of energy consumption, a colour coding system is used, with areas with higher energy consumption ratings displayed in brighter colours. Through this

platform, users can quickly identify highlighted faulty facilities and their precise locations with a simple graphical operation, allowing for timely maintenance and management[10],as shown in Figure 2.

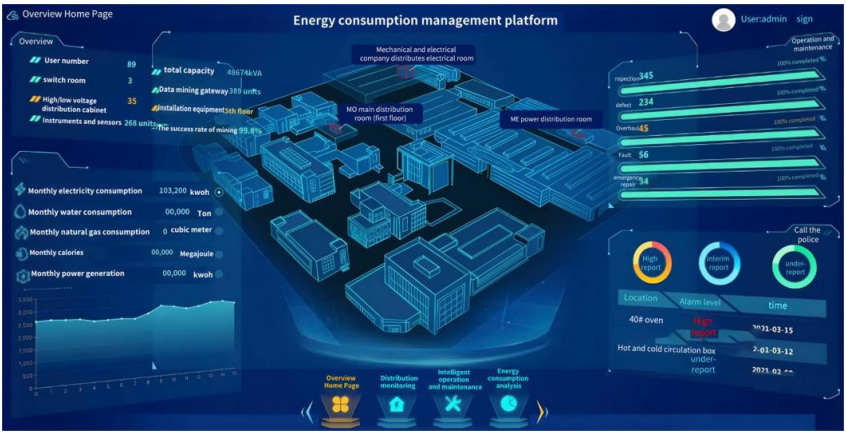


**Fig. 2.** Interface diagram of energy consumption management platform (Source: Xiamen Bonzhan Digital Technology Co.Ltd.)

## 5.2 Information-based management

In the BIM model, the campus building equipment has unique code and QR Code, and the parameter information is integrated in the model, which is convenient for users to quickly locate and read the parameters. Compared with the traditional model, there is no need to go through paper information or on-site inspection, which greatly improves management efficiency. In case of equipment failure, the model information can be directly linked to make preliminary maintenance judgement, track the repair progress in real time, and ensure that the equipment resumes operation in a timely manner.

## 5.3 Intelligent control

Using big data technology, the system can learn the normal energy consumption of the equipment and compare the actual energy consumption. When it exceeds a certain percentage difference, it will highlight possible malfunctions or abnormal usage to remind managers to check. Combined with sensors, the system recognises unoccupied rooms and automatically switches off non-essential equipment or reminds managers to do so to save energy. In addition, the system is linked to the HVAC system to ensure indoor comfort while minimising equipment energy consumption.

### 5.4 Refined Statistics

The Campus Energy Management Platform is a comprehensive platform that displays the total energy consumption and the energy consumption of the internal spaces of individual buildings in a detailed manner through dynamic analysis reports and a variety of charts and graphs. The platform can classify, itemise and partition statistics by time dimension, and provide detailed energy consumption display of equipment systems such as air-conditioning and lighting. Managers can customise the query time to grasp the trend of energy consumption intuitively. At the same time, the platform supports flexible data combination and export to meet diverse management needs. What's more, the platform is equipped with year-on-year and year-on-year analyses, which help managers examine energy-saving effects, set reasonable energy-saving targets and optimise energy-saving plans. This comprehensive and powerful tool provides important support for energy-saving management and sustainable development of the campus.

### 5.5 Penetrating Education

The use of the energy management platform can enhance users' awareness of energy saving and environmental protection through participatory management. Teachers and students are not only the initiators and beneficiaries of energy management, but also the promoters and practitioners of green operation and maintenance. They can use mobile phones, electronic screens and other terminals to visually display daily energy consumption and participate in the process of green campus construction through data sharing, feedback and evaluation. Managers can also adopt green education and spatial environmental control to guide teachers and students to develop energy-saving habits and contribute to the promotion of sustainable green campus development.

## 6 Conclusion

The energy consumption management platform for universities integrates all energy data on campus, predicts energy consumption trends and identifies potential problems by monitoring and analysing by time period and by region. The platform monitors the status of equipment in real time, carries out fault diagnosis, realises energy consumption classification and sub-metering, and provides visual tools to track energy consumption trends. It establishes an early warning mechanism for energy consumption, optimises the management of energy consumption, helps scientific and efficient energy-saving decision-making, and achieves safe, reasonable and scientific energy consumption. The user object of the energy consumption management platform is not only limited to college campuses, but also can be used by various types of large energy users, such as factories, office buildings, its application is extensive, and the management and monitoring of energy consumption is comprehensive. This paper only discusses how to develop and use the energy management platform for college campus buildings more reasonably and scientifically based on BIM technology, hoping that BIM technology and energy management platform can be expanded to more fields and make greater contributions to energy conservation and emission reduction in the world.

## Acknowledgment

Fujian Provincial Department of Education Project (Science and Technology)-Young and Middle-aged Teachers Education and Research Project, JAT220240, Research on Digital Protection of Historical Buildings Based on HBIM Technology; Fujian Jiangxia College School-level Science and Technology Project-Research Talent Cultivation Project, JXZ2021014, Research on the Application of HBIM Technology in the Conservation of Historical Architectural Components in Yantai Mountain, Fuzhou, China.

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