An Application of BIM Technology in Computer-Aided Building Energy Saving Design

Weizhuo Zhao

College of Applied Science.Jiangxi University of Science and Techonology,Ganzhou Jiangxi,341000 China, zwz369975305@163.com

Corresponding author:Weizhuo Zhao, zwz369975305@163.com

Abstract. The global environmental problems are increasingly prominent, and the problem of lack of resources is further highlighted. As the main carrier of energy consumption in modern cities, construction engineering is an important factor affecting global energy consumption. BIM technology, as the main analysis tool of modern building energy technology, takes BIM technology as the main theoretical system as the support. It discusses the applicability of computer-aided architectural design and performance analysis. In this paper, based on the existing problems of a city's architectural design, based on BIM technology collaborative design of the corresponding building energy-saving construction algorithm, integration of the entire architectural design process, analysis of the corresponding architectural design process, process information and the relevant components of the corresponding building materials and building structure, etc., at the same time, this paper will combine the actual project. Finally, based on the energy-saving renovation and optimization of the corresponding building scheme of a university in a city, this paper analyzes the actual cases.

Keywords: BIM technology; computer-aided tools; building energy saving design; planning and layout design; building structure design;
DOI: https://doi.org/10.14733/cadaps.2021.S1.133-143

1. INTRODUCTION

With the development of modern society and the improvement of human material living standards, building, as the material basis of human life, the increasing data year by year brings social prosperity and environmental degradation and energy consumption. The growing concept of sustainable development in architecture is based on the principles of effective use of resources, health and efficiency of use. To realize these principles involves cross-disciplinary work of various disciplines and types of work. Combining the balance of various advantages and disadvantages, one of the effective methods is to regard the construction project and its various parts as a complete life cycle. [1-2]. However, the current energy problems of urban buildings, such as Yang

[3], Xu [4] and Adi et. al [5] are mainly concentrated on three levels. Its technology is different from the traditional two-dimensional plane drawing mode. BIM Technology integrates the comprehensive, complex and multi-disciplinary nature of the building, so as to establish a unified phase Corresponding information database of construction engineering [6].

With the progress of the times, the development of building energy saving technology in foreign countries is progressing. The United States is the first to carry out systematic research and legislation on building energy saving technology. Its main relevant building energy conservation bills, such as the energy policy and conservation act, the national energy policy act, the national energy comprehensive strategy and the latest energy policy act, were formulated. At the same time, the United States also established the corresponding American green building society based on various corresponding bills, and formulated The corresponding evaluation index [7]. The application of BIM technology is relatively early in the United States, but the scope of application is only limited to a few companies that are required to use it and some realize its significance [8]. In the construction of many facilities in the US military, out of the emphasis on management and efficiency, tools with three-dimensional functions and informatization are used to design, in order to digitize and retain all three-dimensional facilities [9-11]. BIM technology has begun to spread among construction companies in the construction industry. However, because BIM technology requires users to have certain professional knowledge and skills, high hardware requirements, and systematicity in the design stage, etc., the popularity of design companies is relatively slow. In the United States, the popularity and application of BIM technology is relatively high, and some governments or owners will take the initiative to require the project to apply unified BIM standards, and even some states have legislation that mandates that large public construction projects in the state must use BIM technology for design , construction, operation and management [12-13]. According to relevant European scholars, building energy conservation needs to be based on the combination of energy-saving technology and energy-saving behavior, as well as the actual transformation of lighting system, HVAC system, and strengthening maintenance.

BIM technology, as the main analysis tool of modern building energy technology, takes BIM technology as the main theoretical system as the support. It discusses the applicability of computer-aided architectural design and performance analysis. In this paper, based on the existing problems of a city's architectural design, based on BIM technology collaborative design of the corresponding building energy-saving construction algorithm, integration of the entire architectural design process, analysis of the corresponding architectural design process, process information and the relevant components of the corresponding building materials and building structure, etc., at the same time, this paper will combine the actual project, put forward the whole city energy saving design scheme of the building. Finally, based on the energy-saving renovation and optimization of the corresponding building scheme of a university in a city, this paper analyzes the actual cases from three aspects of planning and layout design, building monomer design and building structure design.

The corresponding chapters of this paper are arranged as follows: the second section of this paper will specifically analyze the relevant theoretical analysis of urban building energy-saving design under BIM technology, and give the corresponding case analysis. In the third section of this paper, the energy-saving design under BIM technology will be based on the corresponding single building in a city, and the corresponding design will be analyzed and studied. At the end of this paper, we will summarize the article.

2.THEORETICAL ANALYSIS AND CASE STUDY

This section will focus on the analysis and research of the relevant theory of building energy saving technology under BIM technology, and at the same time, it will carry out practical analysis and research for a building case. The main theoretical framework is shown in Figure 1.

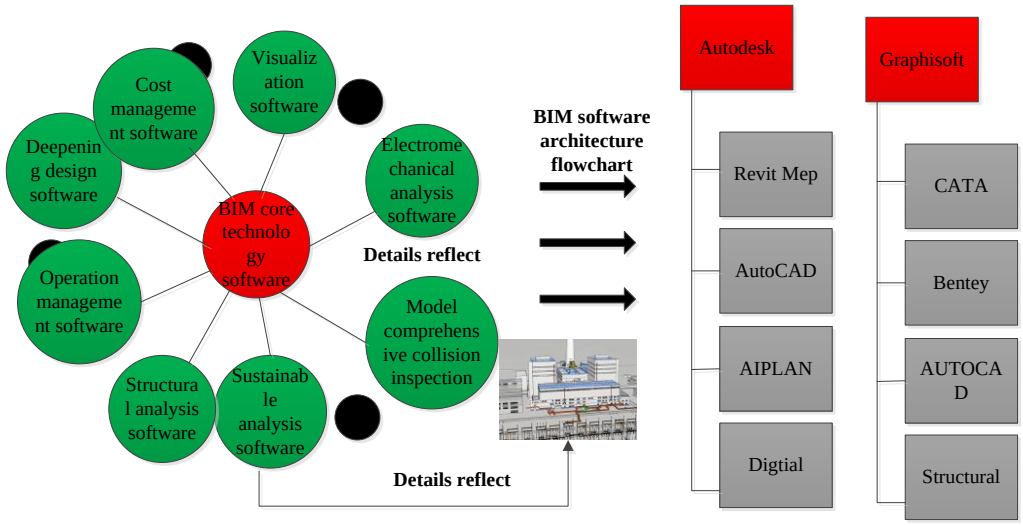

Figure 1: Theoretical analysis and case study framework of urban building energy saving technology under BIM technology.

2.1 Theoretical Analysis of Energy-saving Design of Urban Buildings based on BIM Technology

BIM technology, as the key technology of urban building energy-saving design, its main technical features include five levels of content, corresponding to three-dimensional visualization, simulation, multi-disciplinary coordination, exportability and information continuity. The corresponding technical features are as follows:

A. 3D visualization

BIM is mainly through three-dimensional design, rendering, roaming, animation and the corresponding operation simulation, operation effect and safety aspects of emergency evacuation and construction process. Based on BIM technology, we can show every perspective of the building, so as to grasp the form of the whole space and show the effect.

B. Multidisciplinary coordination

BIM technology can achieve the coordinated development of multi disciplines in the building energy saving system. There are necessary collaborative relationships among the corresponding design units, designers and construction parties or corresponding owners. Through communication with the designer, the system can be operated reasonably through model communication with construction parties in several professional directions. Based on BIM Technology platform, online technology modes such as building operation simulation and information cloud sharing can be realized, and remote collaborative pre collaborative mode can be realized.

C. Exportability

BIM technology can not only realize the two-dimensional drapable characteristics, but also realize the building simulation display in the three-dimensional platform. It supports the output of various technical formats. At the same time, it can also realize the rendering, roaming and analysis of various file formats in different software, so as to reduce the workload of repeated modeling of the whole building system.

D. Information sustainability

BIM extends the concept from the creation of drawings and schedules to the creation, management and communication of building-specific information, and is committed to the quality, accuracy and consistency of information. For graphic products drawn by 2D CAD tools, because the design drawings of a project are drawn by multiple designs, some inconsistencies have to be

accepted, such as the approximate value of the calculation of building area, the way and method of graphic representation. However, for BIM technology, the inconsistent expression of drawing information may cause other team members and other software to be unable to use these data information, so these differences are unacceptable.

BIM realizes the comprehensive utilization and generation of different links through the RE modification and processing of the model. BIM technology can realize the integrity of the information transmission link of the whole building life information cycle.

E. Simulatability

BIM technology can analyze the building ecological analysis based on the virtual building model through simulation, including the analysis of the lighting, sunshine, ventilation, thermal environment and the corresponding noise of the building. At the same time, it can simulate the stress in the structure, the operation effect of the equipment, the emergency evacuation of the corresponding safety and the construction process. At the same time, in the actual simulation process, it can realize the comparison and optimization of various schemes, and finally realize the optimization and more perfect design and construction plan.

Based on the above characteristics, the main energy-saving design are shown in Figure 2. It can be seen from the figure that the main advantages are mainly concentrated in the following points: BIM Technology can provide designers with a variety of convenient and effective design platforms, which can realize the design transformation from two-dimensional to three-dimensional, and BIM based building design can be updated in real time through the model under construction In order to improve the efficiency and flexibility of the whole architectural design, the plane and vertical sections of the building are changed synchronously. BIM technology can provide a multi angle perspective for building energy-saving design, making the building not only solve the simple function, epidermis and engineering content in the scheme stage, but also give full play to the advantages of space visualization, so that the corresponding planarized functional zoning and 3D space design can be organically combined.

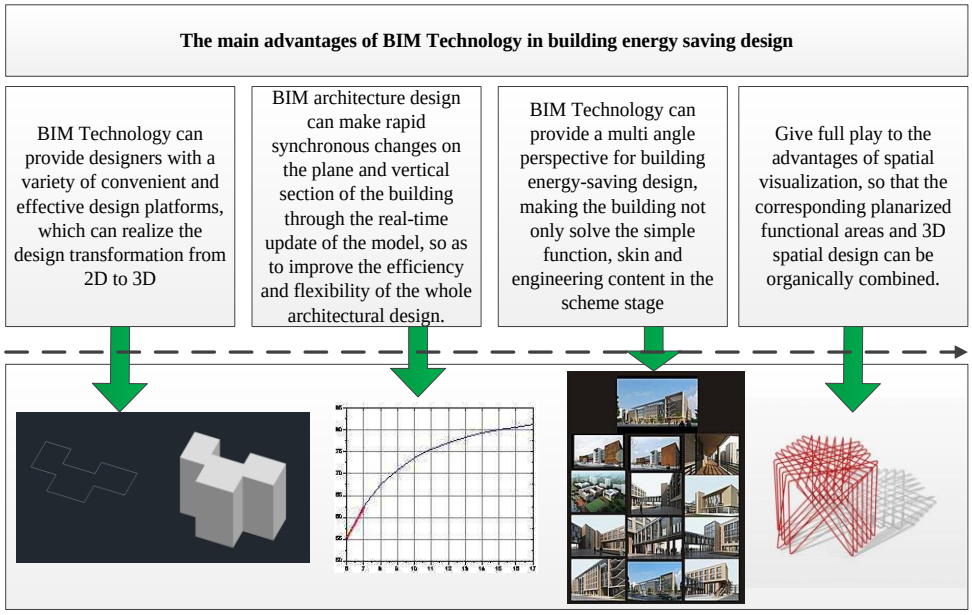

Figure 2: Main advantages of BIM technology in building energy saving design.

Based on this, the corresponding design process of building energy saving is shown in Figure 3. From the figure, we can see that the corresponding design ideas are as follows: Based on the principle of low energy consumption, starting from the comfort of human body, combined with the

local climate characteristics of the building, the passive or active design hand is adopted. The whole process basically follows the design idea of "analysis design evaluation analysis", combined with the construction The distribution of building design process is combined with the implementation of corresponding passive and active sustainable strategies. As a whole, the corresponding BIM technology in the whole design process can realize visualization, which fully considers the local terrain, the corresponding building volume and the corresponding environmental characteristics in the design process. In the actual evaluation and design process, it is necessary to implement the specific analysis of four sections and one environmental protection in the architectural design cycle according to the standards. The corresponding standards provide the architectural design unit with: general layout, plan, elevation, section and corresponding effect drawings of the building. In the whole design process, the corresponding application strategies of BIM technology in the whole design process life cycle of green building permeate the whole building operation mode from the macro to the micro, from the overall to the local, and finally gradually improve the BIM information model from the corresponding rough to the detailed process. At the same time, in the final analysis stage, the concept, planning, scheme design of green building will also be introduced And deepen the design and the corresponding follow-up construction and operation and maintenance stage, so as to finally achieve the details and quality control in the whole building energy-saving design link.

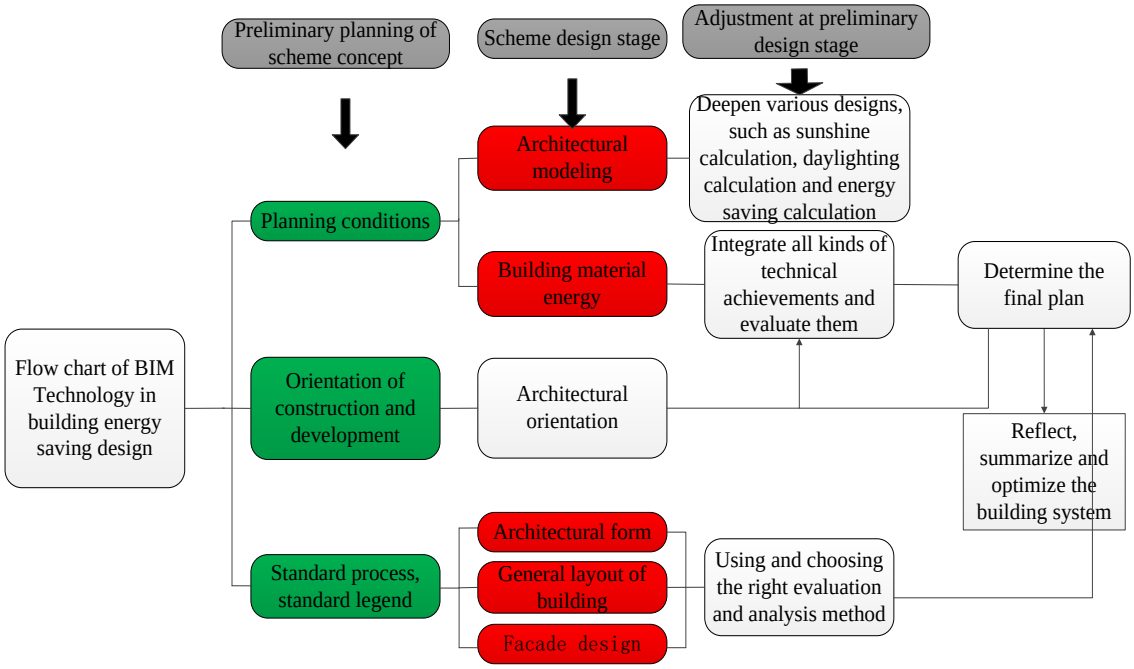

Figure 3: Flow chart of BIM technology in building energy saving design.

2.2 Case Study

The corresponding design flow chart is shown in Figure 4, and the corresponding building form and surrounding environment are shown in Figure 4. From the perspective of the overall architectural design process, through BIM technology, the corresponding model and related software analysis, the environmental performance analysis and evaluation of the environment can be realized. At the corresponding design level, the BIM software is mainly used to simulate the wind field experiment, and the corresponding physical wind tunnel test and wind load test analysis are carried out. For the corresponding curtain wall system design, through BIM software, the heating and cooling

energy consumption of the whole building is effectively reduced, and the effective economic operation of the whole building is realized.

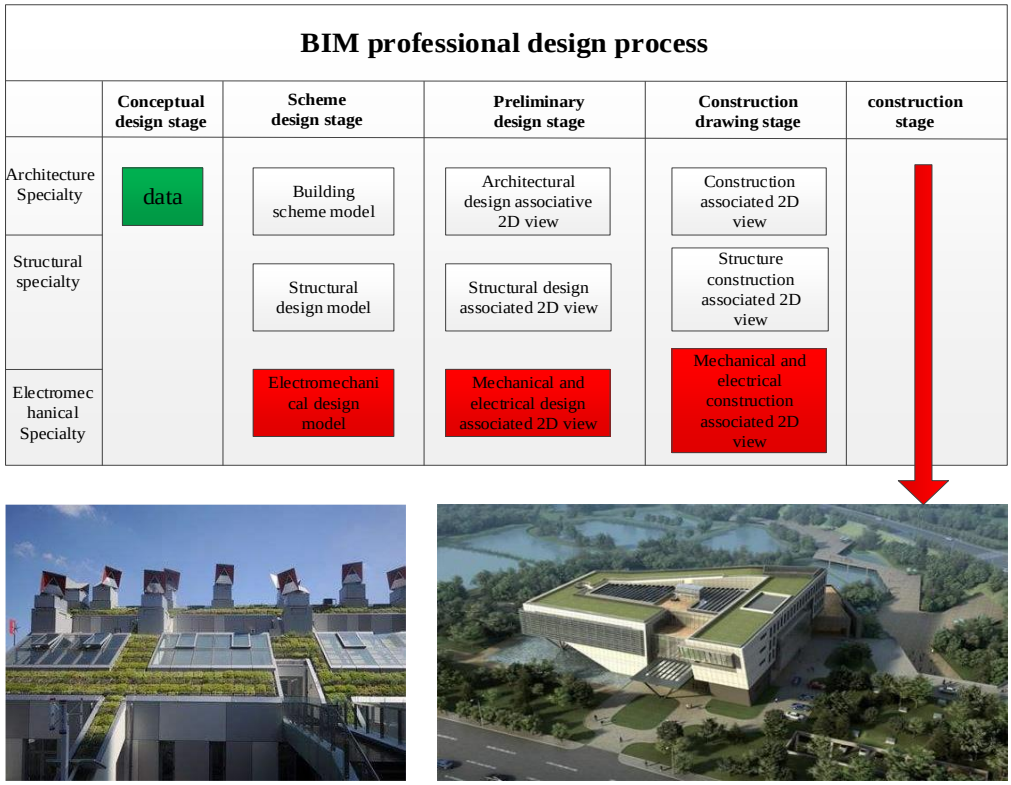

Figure 4: Case analysis.

At the design level of the corresponding water source collection system, the BIM technology is used to realize the simulation analysis of the precipitation in the whole area, so as to realize the comprehensive and effective utilization of the water source inside the building. At the corresponding level of environmental comfort design, through the corresponding BIM technology, the assessment of the air quality of the whole building can be realized, so as to set the indoor environmental parameters reasonably, optimize the system parameters of the corresponding fans, pumps and corresponding equipment of the air conditioning system, so as to realize the low energy consumption operation of the load change control unit throughout the year.

3.ENERGY SAVING DESIGN OF SINGLE BUILDING IN A CITY BASED ON BIM TECHNOLOGY

This section will carry out energy-saving design for an office building in a city, and the mainstream application technology is BIM technology. The corresponding design scheme is shown in Figure 5. The figure shows the corresponding framework scheme of the whole gymnasium. The corresponding sunshine analysis is fully considered in the whole scheme. The energy consumption analysis also maintains the aesthetic feeling and corresponding functional characteristics of the whole building.

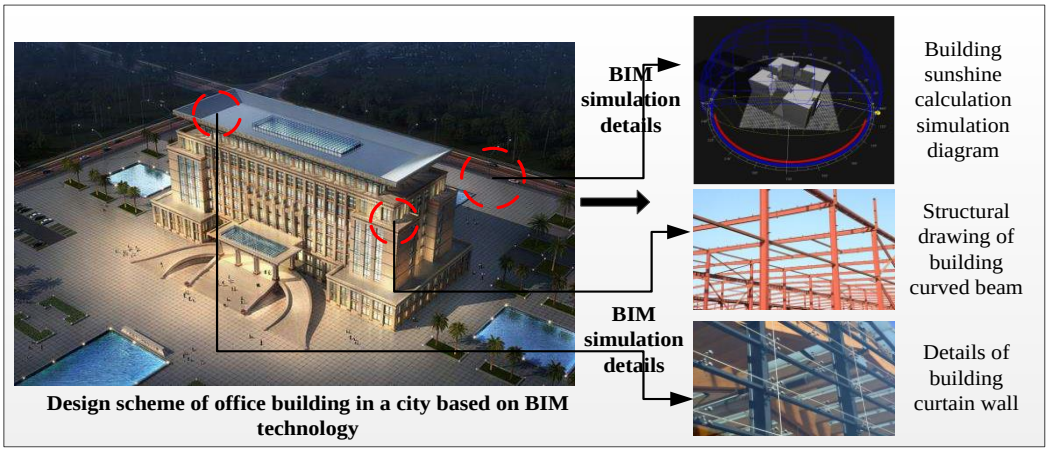

Figure 5: Design scheme of office building in a city based on BIM technology.

From Figure 6, a certain building distance can be reserved in the whole building planning, so as to ensure that the adjacent buildings can receive the corresponding sunshine. According to different seasonal requirements, make full use of the seasonal characteristics for lighting and sunshine. In this section, BIM technology is used to realize the identification of sunshine time and geographic information in the design, so as to simulate the sunshine scheme of the whole building system, and finally realize the intuitive expression of the design.

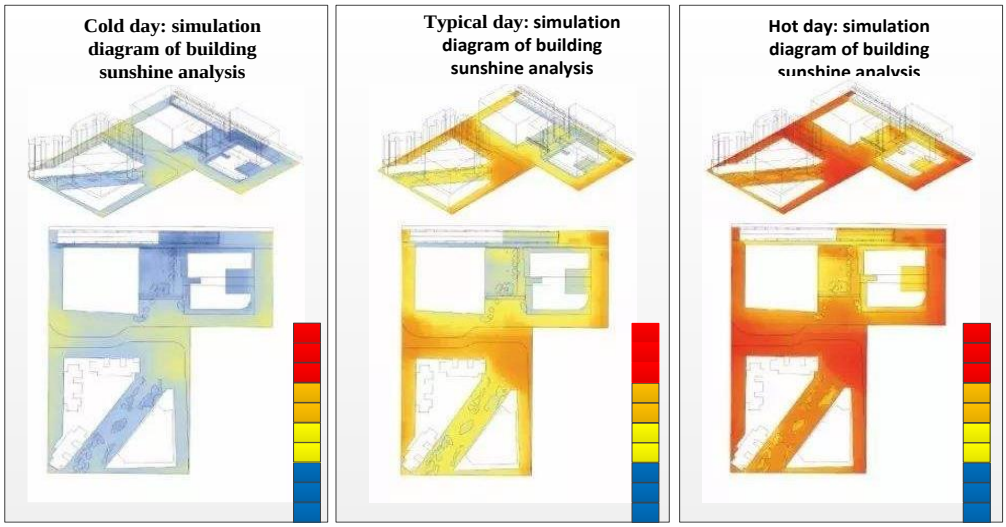

Figure 6: Sunshine analysis simulation diagram of a city office building design scheme based on BIM technology.

Based on this, the corresponding total radiation statistics are shown in Figure 7. It can be seen from the figure that the corresponding total radiation of buildings based on BIM technology can ensure the whole building to be comfortable, so as to realize the land use of the whole building under the condition of meeting the sunshine and the shading of the buildings by the sunshine in the form of scattered high and low, so as to achieve the maximum possible building To receive sunshine and improve the sunshine level of the whole building.

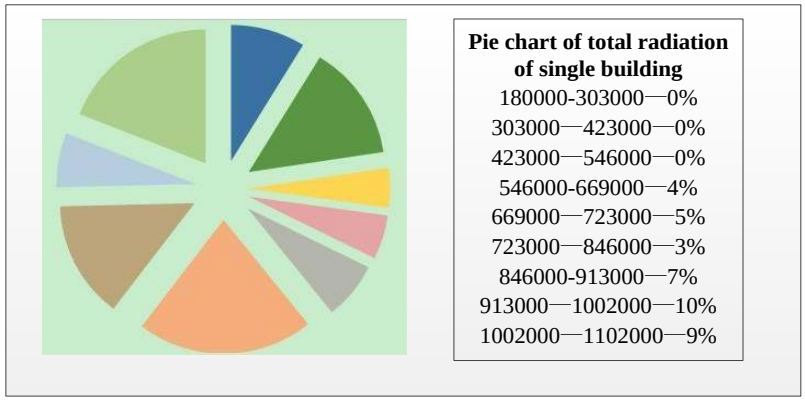

Figure 7: Radiation statistics of a city office building design scheme.

In the corresponding wind field environment analysis, this paper simulates the wind field based on BIM computer-aided software, and the corresponding simulated wind environment diagram is shown in Figure 8. From the diagram, it can be seen that the whole building design is conducive to the indoor ventilation and corresponding outdoor activities of the building, so as to realize the natural ventilation and corresponding energy-saving requirements of the whole building. Figure 9 shows the comparison of energy consumption.

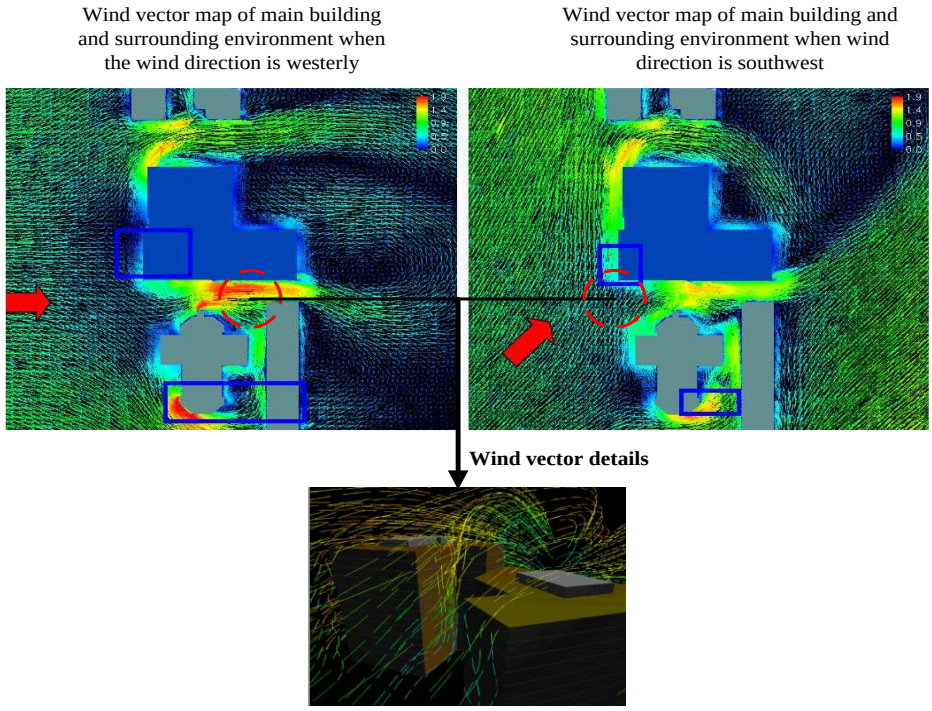

Figure 8: Wind field statistics.

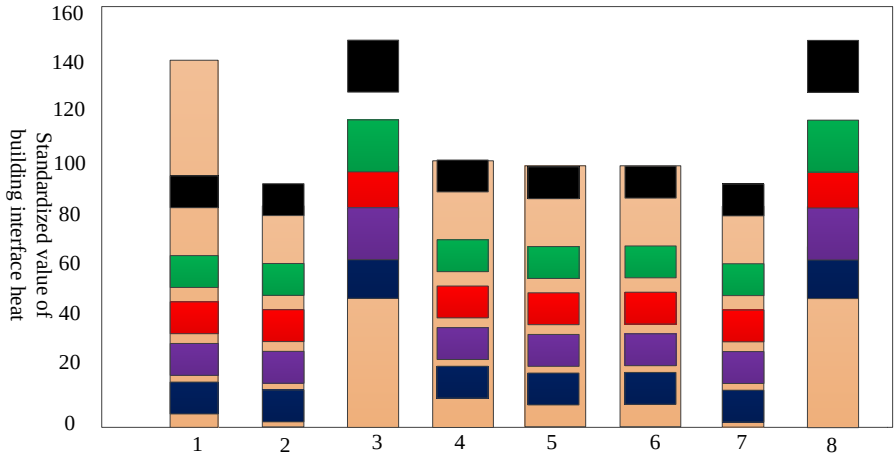

Figure 9: Energy consumption.

The corresponding statistical diagram of building interface heat loss is shown in Figure 10. It can be seen from the figure that the building heat loss after BIM pre simulation has a certain accuracy. Based on the previous simulation, it can also basically avoid the maximum reduction of building heat loss through design.

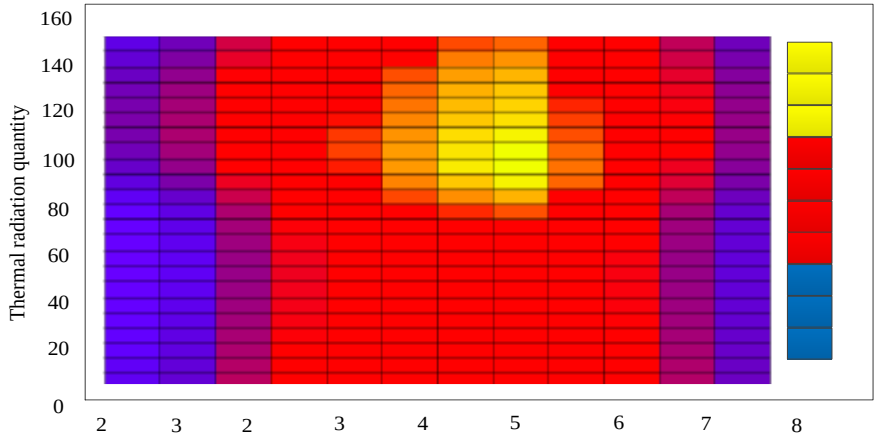

Figure 10: Building heat loss statistics of a city office building design scheme based on BIM technology.

Based on the above design scheme, this paper realizes the energy-saving design of a typical office site in a city, analyzes and calculates it, realizes the natural ventilation of the building and the maximum use of natural lighting, and strengthens the thermal function of the interface. As a whole, the scheme designed in this paper is an advanced, efficient design scheme. In the specific details of the scheme, this paper realizes the natural lighting, natural ventilation, high-efficiency insulation and moisture of the interface and the corresponding insulation performance.

4. CONCLUSIONS

As the main carrier of modern urban energy consumption, building engineering is an important factor affecting global energy consumption. Based on this situation, based on the existing problems of a city's architectural design, and based on BIM technology, this paper designs the corresponding building energy-saving construction algorithm, integrates the whole architectural design process, analyzes the corresponding architectural design process, process information, and the corresponding building materials and construction and other related components, and finally combines the actual project. Finally, based on the corresponding building scheme of a university in a city, this paper carries out the energy-saving transformation and optimization. However, the BIM technology is still in the process of continuous development and improvement, and the establishment of the building information model brings about a huge amount of simulated data processing. The ability to process data is limited. Even projects with relatively simple engineering scales need to spend a lot of time in analysis to obtain relevant simulation data. Therefore, in order to explain the energy-saving design effect that can be achieved by the office building energy-saving design strategy and explain the BIM technology in the realization of building energy-saving design process, the analysis chart in the paper is obtained by simplifying the building model in the study.

Weizhuo Zhao, https://orcid.org/0000-0001-8008-2066

Acknowledgements:
Theoretical Research and Application of BIM in the Whole Life Cycle of Green Buildings, Jiangxi Provincial Department of Education Science and Technology Project, China (Grant No. GJJ171502).

REFERENCES

[1] Li, Y.-C.; Liu, H.; Wang H.-T.: GO-guided direct growth of highly oriented metal–organic framework nanosheet membranes for H2/CO2 separation, Chemical Science, 9(3), 2018, 56-67. http://dx.doi.org/10.1039/C7SC04815G

[2] Yang, Z.; Arto, K.; Stephen, W.-J.: A review of risk management through BIM and BIM-related technologies, Safety Science, 97(3), 2017, 88-98. http://dx.doi.org/10.1016/j.ssci.2015.12.027

[3] Yang, S.-J.; Li, J.-Y.; Hong, R.-J.: Application Study on BIM Technology in Prefabricated Concrete Structure Construction of Senile Apartment, Heart, 36(9), 2014, 872-879. http://dx.doi.org/10.1136/hrt.36.9.872

[4] Xu, X.-H.; Liu, Y.; Li, D.-J.: Effect of shRNA-Mediated Gene Silencing of Bmi-1 Expression on Chemosensitivity of CD44+ Nasopharyngeal Carcinoma Cancer Stem-Like Cells, Technology in Cancer Research & Treatment, 15(5), 2016, 27-35. http://dx.doi.org/10.1177/1533034615599461

[5] Adi, I.; Che, A.; Suhana, J.; Norngainy, M.-T.: Building information modeling (BIM)-based building condition assessment: A survey of water ponding defect on a flat roof, Chemical Research in Chinese Universities, 75(9), 2015, 925-927. http://dx.doi.org/10.11113/jt.v75.5222

[6] Seulki, L.; Jungho, Y.: Discriminant model of BIM acceptance readiness in a construction organization, Ksce Journal of Civil Engineering, 21(3), 2016, 1-10. http://dx.doi.org/10.1007/s12205-016-0555-9

[7] LU, Q.; Lee, S.-H.: Image-Based Technologies for Constructing As-Is Building Information Models for Existing Buildings, Journal of Computing in Civil Engineering, 31(4), 2017, 7005-7014. http://dx.doi.org/10.1061/(ASCE)CP.1943-5487.0000652

[8] Li, B.-P.; Zhang, Z.-G.; Liao X.-F.: Research on BIM Model Creation of Concrete Wind Tunnel Project in Construction Stage, Nucleus, 22(2), 2014, 183-184. http://dx.doi.org/10.1080/09575140220151512

[9] Francesco, G.; Galizia, W.; Hoda, E.: The evolution of molds in manufacturing: from rigid to flexible, Procedia Manufacturing, 3(3), 2019, 319-326. https://doi.org/10.1016/j.promfg.2019.04.039

[10] Maharshi, P.; Singh, S.K.; Gulati, M.; Yadav, A.K.; Garg, V.; Kumari, B.; Gowthamarajan, K.: ANovel Three-pronged Approach for Colon Delivery of Sulfasalazine: Concomitant Use of pH-Responsive, Microbially Triggered Polymers and Liquisolid Technology, Current Drug Delivery, 15(2), 2018, 814-821. http://dx.doi.org/10.2174/1567201815666180320095703

[11] Gavrilov, V.-S.; Kazennov, G.-G.: Method of simulation the asymmetric memory access for solving synchronization problems in multiprocessor systems, Russian Microelectronics, 43(7), 2018, 496-500. http://dx.doi.org/10.1134/S1063739714070087

[12] Abdulaal, B.; Bouferguène, A.; Al-Hussein, M.: Benchmark Alberta's architectural, engineering, and construction industry knowledge of building information modelling (BIM), Canadian Journal of Civil Engineering, 44(1), 2017, 59-67. http://dx.doi.org/info:doi/10.1139/cjce-2014-0296

[13] Ramadan, B.-S.; Sari, G.-L.; Rosmalina, R.-T.; Effendi, A.-J.: An overview of electrokinetic soil flushing and its effect on bioremediation of hydrocarbon contaminated soil, Journal of Environmental Management, 218(4), 2018, 309-321. http://dx.doi.org/10.1016/j.jenvman.2018.04.065