Internet of Things and Computer-aided Interaction of Energy Saving Design Method and Realization of intelligent Buildings

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Abstract. The energy consumption of civil and industrial buildings is an important aspect and link of urban low-carbon energy saving construction. In the existing green building design, architectural designers mainly choose to adopt certain design strategies for qualitative design according to experience and actual engineering conditions, but there is no accurate quantitative reference. This traditional design method is not conducive to the comparison of advantages and disadvantages of different design strategies, and cannot alleviate the contradiction between different influencing factors according to local conditions. This paper considers the climate characteristic of the region in central China, by means of computer aided design technology, discusses the architectural form and the layout of the quantitative design method, are analyzed in detail under different simplified architecture configuration in the aspect of thermal radiation heat gain, ventilation, lighting, and this method has been proved by practical cases in the construction of the feasibility of the application in the design of ventilation and lighting. To study the energy saving strategy of passive buildings, building energy consumption model is generated based on the original building model, and data is shared through the processed data of energy consumptions.

Keywords: Internet of things; energy conservation; computer-aided interaction; intelligent buildings; design method
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1 INTRODUCTION

With the acceleration of China's urbanization process and the improvement of people's requirements for the comfort of living environment, building energy consumption continues to rise [1]. Besides, the energy consumption will gradually increase to more than 30% in the future [2].

In the face of building energy growth, energy conservation design is increasingly important, passive building design through high-performance envelope and high air tightness passive strategy, the applications of green energy reduce the dependence on active heating and cooling system, so as to minimize the building energy demand. Building performance simulation is the basis of energy saving design of passive buildings. The model data transmission and sharing of computer aided technology provide a solution for multi-disciplinary joint analysis.

In the existing green building design, designers mainly adopt certain design strategies to conduct qualitative design based on experience and actual engineering conditions [3]. After the completion of the building, a variety of technical means are used to test the design work, and if necessary, data collection in the actual operation state is needed to evaluate the actual role of the design method in building energy conservation. Practice has proved that compared with traditional buildings without green design concept, green construction technology and green building materials, most of such buildings can reduce building energy consumption to help the utilization efficiency of light, wind and other natural resources [4]. However, such a qualitative design method cannot provide a more accurate quantitative reference in the design process, and cannot compare the advantages and disadvantages of different design methods, so it cannot further optimize the design system. On the other hand, without quantitative design methods, it is difficult for designers to put forward design concepts and principles tailored to local conditions through the complex connection between climate and architecture [5], so as to make full use of the advantages of different regions and alleviate the contradictions between different related factors to the greatest extent. The breakthroughs in building energy conservation. With the continuous development of information technology and intelligent trend is spreading in various industries, computer aided design of engineering and product design has been widely used, can realize the different schemes are a large number of complicated calculation, comparison and analysis, prompted the experience design method of dominant constantly been replaced with a quantitative basis for precision design method [6]. This also provides an important basis for the wider and scientific application of building energy conservation technology.

In the existing green building design, designers mainly choose to adopt certain design strategies for qualitative design based on experience and actual engineering conditions, but there is no accurate quantitative reference. This traditional design method is not conducive to the comparison of advantages and disadvantages of different design strategies, and cannot alleviate the contradiction between different influencing factors according to local conditions. Combined with relevant regional climate characteristics, by means of computer aided design technology, discusses the architectural form and the layout of the quantitative design method, are analyzed in detail under different simplified architecture configuration in the aspect of thermal radiation heat gain, ventilation, lighting, and this method has been proved by actual case the feasibility of the application in the design of building ventilation, lighting.

2 RELATED STUDIES

Currently, many scholars have carried out many optimization studies on energy-saving design based on computer aided technology for building performance simulation. Png et al. [7] conducted energy consumption simulation in the EnergyPlus environment through Revit modeling and optimized building energy consumption based on genetic algorithm. Akab et al. [8] used computer aided server and Open Studio convert modelsto simulate building energy consumption by developing the extension plug-in. Mirahadi et al. [9] developed Optimo, a node package based on Dynamo platform, which takes NSGA-II algorithm as the core and obtains the ideal Pareto frontier through iterative search, providing a multi-objective optimization tool for architectural design. Javed et al. [10] simulated the lighting, ventilation and energy consumption of buildings through BIM model, and conducted sensitivity analysis on different window ratios and shading coefficients to assist architectural design. Based on Dynamo platform, Minoli et al. [11] developed a data interaction channel with Green Building Studio. Energy consumption simulation was carried out through cloud computing, lighting index calculation was carried out by Autodesk cloud rendering service, and multi-objective optimization of energy saving measures was carried out with NSGA II algorithm as the core.

The goal of building energy consumption monitoring system is to complete the whole parameter and whole process control of building energy consumption, which integrates the basic functions. To meet the national energy conservation management indicators and technical requirements in public buildings, through various forms of technology to achieve energy conservation goals. On the basis of dynamic monitoring and data of energy consumption, relevant energy consumption management can be completed, and ultimately achieve emission reduction effect. Among them, the Internet of Things technology is an essential form of technology, which has a very important impact on the collection of energy consumption information [12]. The application of Internet of Things technology in building energy consumption monitoring can be broadly used in two aspects: environmental monitoring and energy conservation management.

(1) Environmental monitoring

Internet of things technology can be within the buildings on illumination, temperature and humidity, noise, such as real-time monitoring project, to determine the specific locations for energy consumption and environmental impact caused by the monitoring function through the sensor information acquisition, information transmission and converting the proceeds into the corresponding monitoring system platform, by the management or automatic control software for the corresponding equipment running condition adjustment, To ensure that the energy consumption is kept within the appropriate range. This Internet of Things technology based on environmental monitoring can also effectively improve environmental quality in all periods of time when it is linked to power-consuming systems such as air conditioners.

(2) Energy-saving management

Internet of things technology for energy conservation management, mainly is its connection with energy consumption monitoring instrument, the building's electricity, water, gas, heating energy consumption situation of collecting, sorting and analysis respectively, using the data of dig deep formation energy consumption model, and then to building energy consumption is too large and energy-saving method to provide technical support.

In terms of the current construction of energy consumption monitoring system of public buildings in China, Internet of Things technology has become an indispensable technical guarantee. Therefore, this article under the computer-aided, in central China's inland areas, for example and discusses the construction of the climate is suitable form ventilated daylighting quantitative design method and optimization strategy, and in view of the existing buildings is a discuss the design method of transformation of ventilation and lighting applications, computer aided building energy efficiency design is realized based on the quantitative in the practical application in engineering, At the same time, it also provides reference for building energy saving design of similar buildings.

3 RESEARCH ON THE ENERGY SAVING DESIGN METHOD AND REALIZATION BASED ON INTERNET OF THINGS AND COMPUTER-AIDED INTERACTION

3.1 Application of Internet of Things in Building Energy Conservation

According to the characteristics of existing intelligent buildings, two methods are provided for temperature and humidity control. The intelligent fan control terminal is used to manage the speed and operation of the fan and allow remote adjustment of fan gears. The temperature and humidity control system is composed of temperature and humidity sensing, environmental intelligence control terminal, and air conditioner. Based on the actual case, intellisense module, intelligent environment system is mainly composed of temperature and humidity environment intelligence control terminal, wireless control module (controlled air conditioning with self-learning function), the school of existing air conditioning, can expand the gateway access to the intelligence environment control platform, support mobile terminal and PC equipment remote control and management. The temperature and humidity intelligent sensing module detects the ambient temperature and humidity with high speed and precision and sends the data to the environmental intelligent control terminal. The eAC terminal controls the air conditioner based on the control policy configured manually or remotely. The wireless control module is responsible for air conditioning equipment, as shown in Figure 1. The cloud computing technology is used to realize the long-term storage and accurate display of real-time data of the sensor module through the cloud platform, and control the monitoring data generated by intelligent hardware devices such as air conditioners, which is convenient for long-term management.

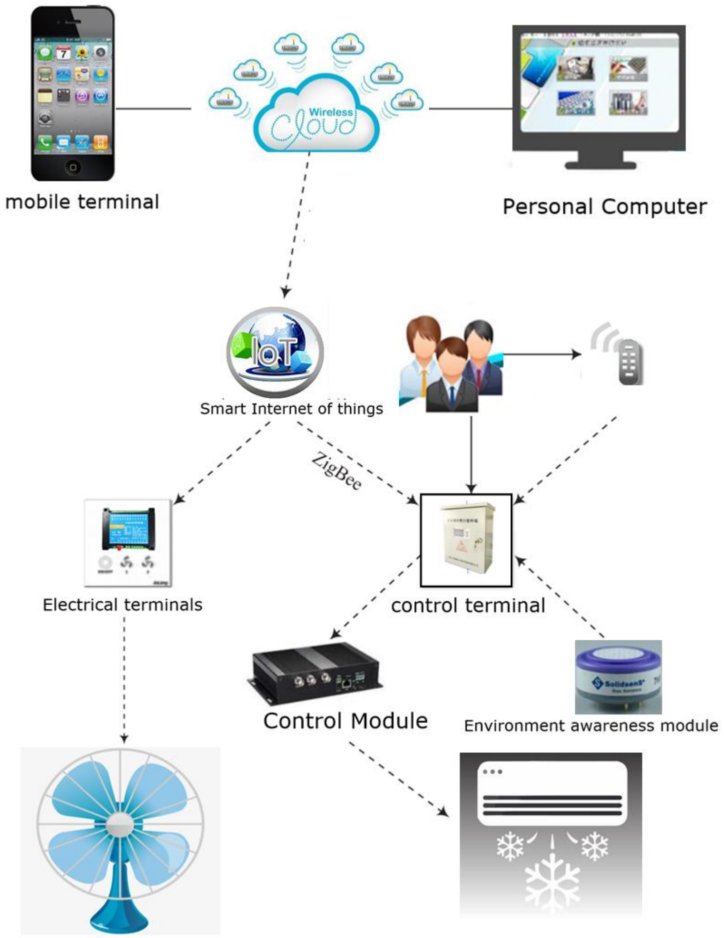

Figure 1: Civil building Interaction diagram of Internet of Things and building energy conservation.

3.2 Computer-Aided Interaction Design

The computer-aided design method focuses on the use of energy conservation designing method to create a graphic plan. In this study, the building performance analysis model provided by Revit is used to carry out joint simulation of building performance by using Grasshopper as a platform to invoke the energy consumption simulation engine OpenStudio and the LadybugTools component package with Daysim as the core. The fixed sunshade, window wall ratio, and related parameters of thermal insulation layer is set to passive energy saving factor, refrigeration, heating energy consumption and lighting consumption of three indicators as the fitness function of the checks and balances, provided by Wallacei NSGA-Ⅱ algorithm for multi-objective optimization and get the pareto frontier solution set, the passive energy saving factor index change trend, that makes energy saving decisions for passive buildings.

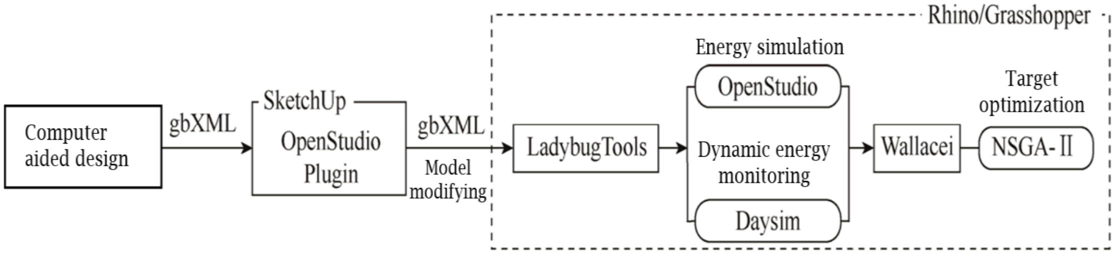

Figure 2: Multi-target optimization process of building performance.

3.3 Building Energy Consumption and Energy Saving Analysis

To verify the visual effect of the proposed coloring method, this study discussed with the building energy consumption and energy saving analysis. For civil buildings, electricity consumption is the source of most of the energy consumption, and the energy consumption that has little relation with the rule of use and outdoor meteorological conditions is called fixed energy consumption of teaching buildings, such as the energy consumption of the slide projector for teaching; The energy consumption in campus buildings greatly affected by uncertain factors such as the number of students and climate is defined as non-fixed energy consumption. For example, the energy consumption generated by students using water heaters in classroom self-study is highly unpredictable. The calculation relation of non-fixed energy consumption is shown in Equation (1).

$$W_f = W - W_g = W - T \times N \times P \tag{1}$$

Where: W_f is the building's daily non-fixed energy consumption, kW·h; W is the total daily energy consumption of the building, kW·h; W_g is fixed energy consumption per day, kW·h; T is the duration, h; N is the number of electrical equipment; P is the total power consumption of teaching equipment in each classroom in the teaching building, kW.

The total daily energy consumption of the teaching building W can be obtained through the energy consumption monitoring system. According to the work and rest time, the course duration T is a fixed value of 1.58h, and the standby power rate P of the teaching and learning equipment of the single-seat teaching room in the teaching building is a fixed value of 0.7kW. After the investigation and course arrangement. The number of daily courses N of the teaching building can be obtained, from which the daily non-fixed energy consumption W_f of the teaching building can be calculated.

4 ANALYSIS OF RESULTS

4.1 Computer-Aided Realized Results

Computer-aided design techniques and methods are used to perform the data analysis. When the energy consumption of heating and air conditioning of the designed building is greater than that of the reference building, the design parameters should be adjusted to recalculate until the energy consumption of heating and air conditioning of the designed building is not greater than that of the reference building [13]. The shape, size, orientation, internal space division and use function of the reference building should be exactly the same as that of the designed building. Reference building envelope thermal performance parameters should be fully in line with the standard. The three-dimensional analysis diagram is drawn by using the technology and theory of computer-aided design, which is the same as the visualization effect obtained by the graph. In the analysis, the three-dimensional model is cut and modified with computer software, the required target elements and indicators are added, and the output result is the scheme of transparent channel. Then, the 3D model image is imported into the graphic design software, and the complete 3D model image is finally output through the beautification process. After color rendering and position marking in different colors, the appearance characteristics of the green energy-saving building structure can be clearly understood. The results are shown in Figure 3.

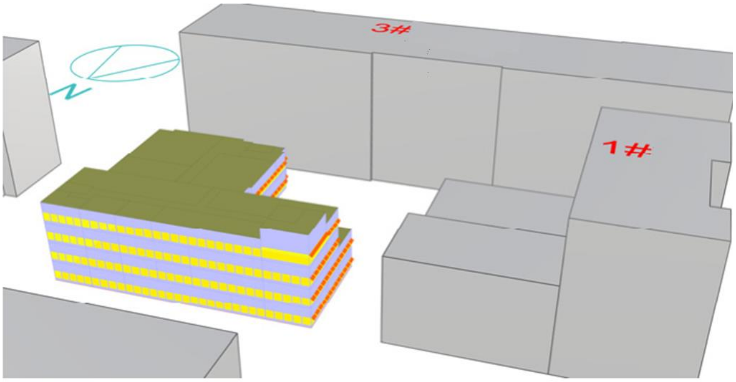

Figure 3: Building energy consumption model of the study.

When energy management to rise to the Internet of things application level, is for a lot of monomer of the intelligent building energy management for another integration, allowing users at this level, the cognition to the energy consumption more motivation, energy conservation and management of the implementation of the plan as a whole, interaction and human nature, and based on the Internet of things application platform to create a comprehensive energy management service system, To meet the rising energy needs of society in the future. After the completion of the system, in the whole life cycle of energy consumption and energy saving of building complexes, it can realize real-time monitoring of energy consumption, management of key energy consumption equipment, statistical analysis of energy consumption, analysis report of energy consumption, maintenance of energy consumption data, system configuration management, diagnosis and analysis of energy saving and other functions. The system obtains the real-time data from the data collector by periodical rotation, and can process the received data synchronously and asynchronously. The system has OPC Client, ODBC, bus (Modbus, BACnet, etc.), file (.csv and.xml) and manual input to complete the collection of real-time energy consumption data, real-time monitoring of the building's overall energy consumption, classified energy consumption, classified energy consumption and other items, and timely detection of energy consumption abnormalities. It provides the basis for statistical analysis of energy consumption, as Figure 4 shows.

The real-time monitoring diagram of overall building energy consumption is shown in Figure.5. Energy-saving diagnosis analysis is based on Internet of things in the database by the accumulation of energy consumption, energy efficiency history data, in view of the current unreasonable power system operating energy consumption (including the loopholes in abnormal energy consumption, energy consumption, and so on and so forth) diagnosis, and concluded in the form of statistical graph diagnosis report, provide moments of each system and the accumulative energy efficiency calculation data, automatically generated energy consumption analysis and diagnosis report. As the basis of energy saving operation and transformation.

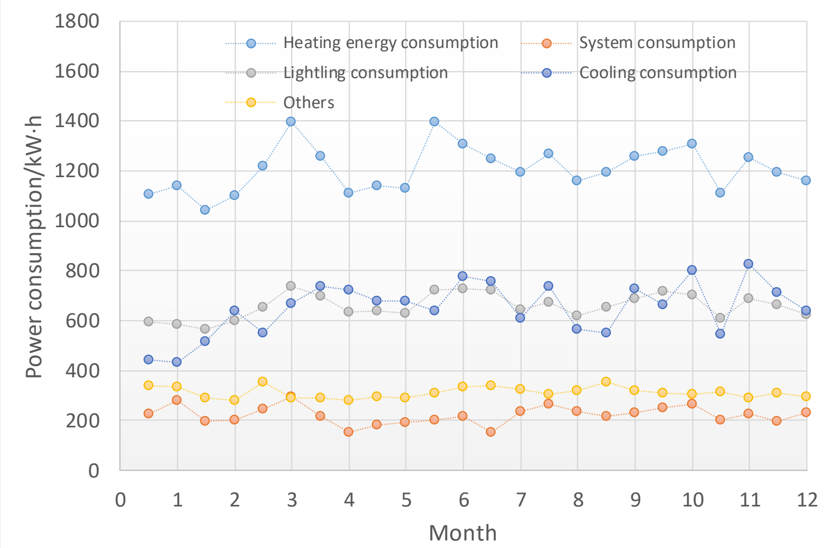

Figure 4: Annual energy consumption statistics chart.

Through energy saving diagnosis and analysis, the problems of energy waste and low operating efficiency of equipment in the system are found, high-consumption areas and equipment are identified, and targeted energy saving transformation is carried out to explore energy saving potential, strengthen energy management and improve energy utilization efficiency. Through energy consumption analysis, it is found that the building belongs to high energy consumption area and needs energy saving reform. Make energy use plan according to current energy use situation. According to energy demand, formulate energy procurement, production and supply plans to ensure purposeful production and planned use, ensure stable energy production and reasonable and frugal energy use to avoid waste. For example, the power consumption of the device is estimated based on the total current and voltage of the device. The energy of air conditioner is estimated based on temperature, area, and building structure, and then the total energy consumption of an office is obtained. With a reasonable budget, we can solve the problem that there is no reference data when the financial budget is made at the beginning of the year, and we can initially find the unreasonable place of electricity consumption by comparing the budget energy consumption with the actual consumption.

4.2 System Functions to be Developed

Scientific calculation, record and display energy-saving reconstruct each item of equipment or system energy saving energy management regulation of section, record and display the statistics were measured from every building energy-saving renovation work or systemic management regulation work and can be accumulated amount of energy conservation, through the contrast analysis, shows that by adopting energy-saving measures, energy-using units can clearly understand the real effect of the reform. The system can establish a set of expert system, mainly including the following knowledge: knowledge base of energy-saving measures, some enterprises have adopted effective energy-saving measures for various types of buildings, communication equipment, power equipment and building energy-saving knowledge. Building 2# is the research object and data set of computer-aided design.

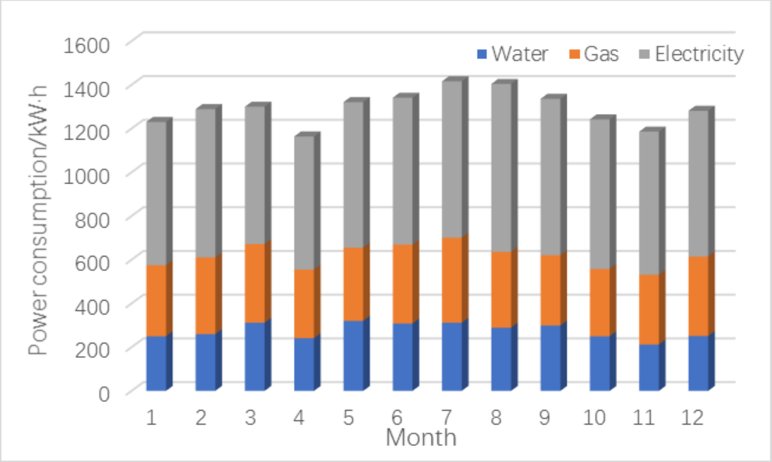

Figure 5: Classified statistical results of building energy consumption.

Time based on collaborative software for urban building consumption in the field of energy saving management software platform Synchro EMS, energy management system is studied in the realization of information access methods, will be a number (in the park construction of basic information and use of electricity, gas, oil, coal, water and energy resources consumption information in two ways, The front-end communication adaption and OPC are used to report to the superior energy consumption supervision center, process, and publish energy consumption data, comprehensively diagnose and evaluate building energy consumption, and tap energy saving potential. On the basis of the level of city energy management functions, such as real-time monitoring, key energy-consuming equipment energy consumption management and statistical analysis of energy consumption, energy consumption analysis and energy consumption data maintenance, system configuration and management, energy saving diagnosis analysis, and other functions, and puts forward the function of the system can improve and meet the demand of higher level of energy management. As presented in Figure.5， the energy consumption of electricity, gas and water is 41.55%,26.04% and 32.41% respectively.

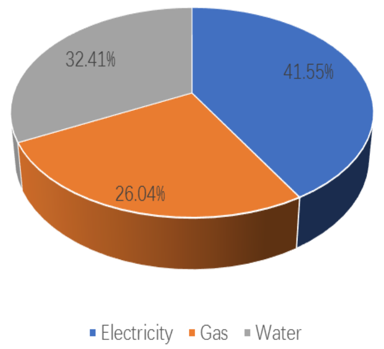

Figure 6: Internet of things statistical energy consumption classification results.

With the computer aided model of the 2# building as the data source and Grasshopper platform, the model and model attributes are parameterized. Using the same model, building energy consumption simulation and building natural lighting simulation are carried out simultaneously, and variables and targets are optimized for multi-objective design, as shown in Figure 12. It can be seen that the electricity consumption for heating, cooling, lighting, systems and others is 20.78%, 13.02%, 16.20%, 22.53 and 27.47% respectively.

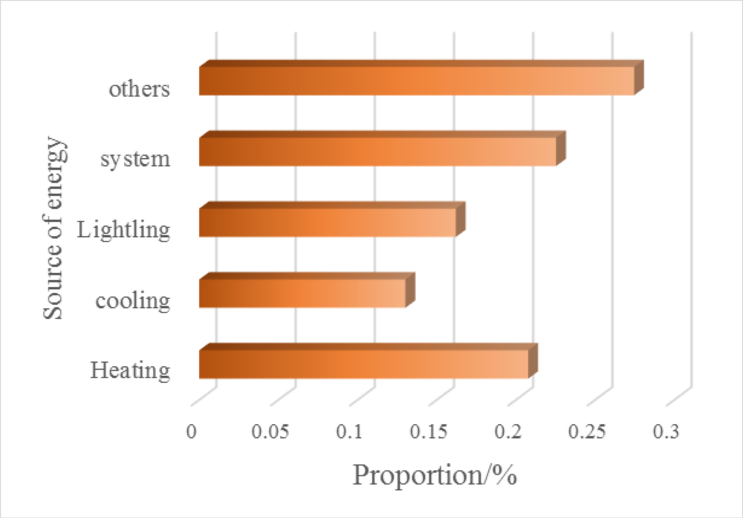

Figure 7: Internet of Things counts energy sources.

4.3 Analysis Results of Visual Communication Technology and Art in New Media Scenes

The building energy saving design part includes the building energy saving design, energy saving and efficient lighting, energy efficient system and equipment, energy recovery device, the use of renewable energy and other aspects of the design requirements. In order to meet the requirements of green building, the selection of materials should strictly control the content of harmful substances in concrete admixtures to avoid harmful substances in building materials causing damage to human health, so as to achieve the requirements of green environmental protection; At the same time, the use of high-performance concrete as far as possible to reduce the size of the beam column section of the building structure, and improve the durability of the structure, and the use of high strength steel, in order to achieve the purpose of reducing the amount of steel; Cast-in-place concrete uses ready-mixed concrete to reduce noise and dust pollution in construction site, save energy and resources, and reduce material loss; Sand aerated blocks are used in the wall design of the project. The main material of sand aerated blocks is silica tailing sand, which is the waste generated in the extraction process of raw materials for the production of flat glass, accounting for more than 30% of the total amount of sand aerated raw materials. Aiming at material saving and material resource utilization, the statistical process of recyclable materials will be introduced in detail in the strategy realization part of the design.

The consumer power characteristics data set VD for clustering includes 3 categories data. The fuzzy C-means method was adopted to initialize the number of clusters C =3 and the fuzzy degree coefficient M =2. Clustering was expanded in subspaces L1, L2 and L3 respectively, and the clustering results of electricity consumption and load characteristics were obtained as shown in Figure 3The fuzzy C-means method was adopted to initialize the number of clusters C =3 and the fuzzy degree coefficient M =2. Clustering was expanded in subspaces L1, L2 and L3 respectively, and the clustering results of electricity consumption and load characteristics were obtained as shown in Figure 9.

Make energy use plan according to current energy use situation. According to energy demand, formulate energy procurement, production and supply plans to ensure purposeful production and planned use, ensure stable energy production and reasonable and frugal energy use to avoid waste. For example, the power consumption of the device is estimated based on the total current and voltage of the device. The energy consumption of the air conditioner is estimated based on temperature, area, and building structure, and then the total energy consumption of an office is obtained. With a reasonable budget, we can solve the problem that there is no reference data when the financial budget is made at the beginning of the year, and we can initially find the unreasonable place of electricity consumption by comparing the budget consumption with the actual energy consumption, and provide data basis for the implementation of energy saving measures in places with high energy consumption.

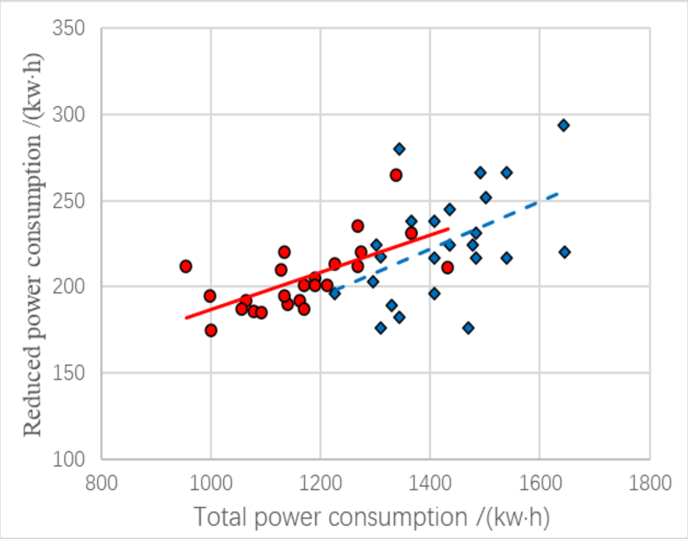

Figure 8: Relationship between reduced power consumption and total power consumption.

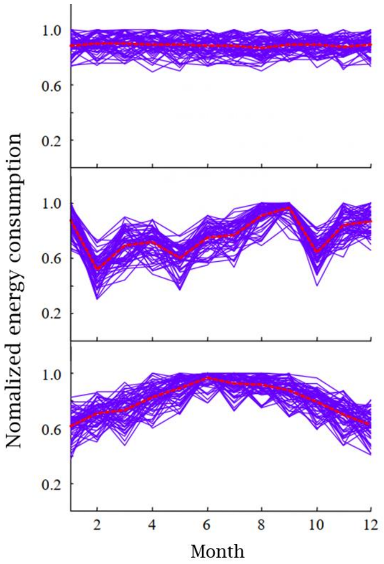

Figure 9: Prediction results of electricity consumption under different algorithms.

5 CONCLUSION

In order to solve the problem of high energy consumption of traditional buildings, especially the difficulty in energy saving of air conditioning, the intelligent monitoring platform of energy consumption of green buildings is constructed by using Internet of Things technology, and the air conditioning monitoring model is built by integrating computer aided methods, and the air conditioning monitoring subsystem is designed to achieve the effect of energy reduction and significant cost advantage. The application of cloud monitoring platform realizes the control of user electricity quantity data and energy consumption information. The huge advantages of the Internet of Things in the energy saving of campus buildings can help realize the goals of real energy saving, high efficiency, safety and low consumption, and meet the requirements of the state to build a conservation-oriented society.

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