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Analysis of Influencing Factors of Green Building Energy Consumption Based on Genetic Algorithm

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Abstract: With the advancement of modernization, high energy consumption buildings can no longer meet the needs of social development. Under the background of low carbon and energy saving, the development of green buildings has become the only way, but its energy-saving design effect needs to be further studied. Aiming at lighting and energy consumption, this study carried out multi-factor optimization analysis based on genetic algorithm on factors such as windowing ratio, wall heat transfer coefficient, window heat transfer coefficient, window transmittance and roof insulation coefficient. Firstly, the theory and technical scheme of applying data mining technology to solve the energy-saving design problems of different buildings are proposed and implemented, including the design of new and existing buildings, as well as the determination of decisive parameters and non-decisive parameters. Secondly, computer simulation and theoretical analysis are used to optimize the analysis of the building scheme, so as to find the optimal design range of each influencing factor and the optimal design method of green low-energy building. Multi-factor optimization theory and genetic algorithm principle are summarized, and the heat transfer coefficient of external wall and window of the building is selected as the optimization variable, so as to achieve low energy consumption and enclosure cost of the building. Aiming at better thermal comfort, an optimization model was established. Finally, through empirical research, an energy-saving plan was designed, and genetic algorithm was used to obtain the optimal solution for maximizing the incremental benefits obtained by unit input incremental cost. The results indicate that the ideal incremental benefits come from a reasonable and effective combination of technologies, mainly from air conditioning systems and lighting systems; the setting of the benchmark return rate will directly affect the optimization effect of energy-saving plans, providing decision-makers with the optimal combination of energy-saving technologies.

Keywords: energy saving scheme; genetic algorithm; green building; incremental benefit; multi-factor optimization

1 INTRODUCTION

The concept of green building is an environmentally friendly building proposed based on the concept of sustainable development. It is an inevitable trend of the development of today's construction industry. Scholars at home and abroad have carried out a series of studies on green building. At present, the research on green building mainly focuses on the following aspects: (1) Study on the evaluation index system of green building. Through scientific analysis and demonstration of the selection of indicators and the assignment of index weights, a green building evaluation index system has been constructed from different perspectives [1, 2]. Based on the perspective of the whole life cycle, the benefits of green building are decomposed into environmental benefits, economic benefits, social benefits, etc., and included into the evaluation index system of green building. The comprehensive benefit evaluation model is built to analyze and study the impact of energy consumption on green buildings and provide decision-makers of green buildings [3]. (2) Study on evaluation methods of green building. In order to promote the quantitative development of green building evaluation, many scholars apply mathematical models to the evaluation of green building, so that the results of green building evaluation can be quantified. At present, the widely used mathematical models include comprehensive evaluation method [4], fuzzy analytic hierarchy process [5], cluster evaluation method, BP neural network evaluation method [6], etc. (3) Study on the impact of green building energy consumption. Through the analysis of statistical data, it is concluded that the incremental cost of green buildings per square meter under different building design levels is mainly caused by adopting energy-saving measures. Therefore, based on multiple perspectives of influencing factors and incentive mechanism, economic benefits of green building related parties can be studied to actively promote green building [7].

At present, the research scope of green building is wide, but mainly focuses on the construction of green building evaluation index system, the selection of evaluation methods and the assessment of energy consumption impact of the whole life cycle. Among them, most of the studies related to the impact of energy consumption start from a macro perspective and build overall evaluation models based on different perspectives. There is no relevant standard for the impact of energy consumption on green buildings. Building energy conservation is an important component of green building evaluation. Due to the complexity of green building itself, it is very difficult to evaluate its overall energy consumption impact. Therefore, this paper selects energy-saving projects of green buildings to study their influence on local energy consumption of green buildings, and on this basis, carries out energy-saving optimization, so as to achieve the highest cost performance of energy-saving projects of green buildings. Due to the large proportion of energy-saving projects in green buildings, the selection of energy-saving plans will directly affect the incremental costs and benefits. Whether the energy consumption impact of energy-saving plans can be effectively evaluated is related to the scientific decision-making ability of developers. Therefore, it is of great significance to select and optimize energy-saving solutions based on minimizing incremental costs and maximizing incremental benefits.

To sum up, there are few studies on the incremental benefit of green buildings. The incremental cost of building energy conservation projects is the main component of the cost of green buildings and the key to cost control, while maximizing the incremental benefit generated by unit incremental cost is the most important content. Therefore, this paper intends to choose the energy-saving scheme of green building and analyze the comprehensive benefit of the energy-saving project of green building. Aiming at the goals of lighting and energy consumption, this study conducted multi-factor optimization analysis based on genetic algorithm for factors such as windowing ratio, wall heat transfer coefficient, window heat transfer coefficient, window transmittance, roof insulation coefficient, etc., built multiple models, used advanced genetic algorithm to predict building energy consumption, and found a genetic algorithm model that could adapt to building performance design. It provides an important basis for energy saving scheme of green building. The first part is an introduction, the second part is an introduction to relevant work, the third part is an analysis of influencing factors of green building energy consumption, the fourth part is similation, and the fifth part is a conclusion.

2 RELATED WORK

Incremental cost-effectiveness of green building is the focus of research. As a new type of investment, the benefits of green building naturally attract the attention of all sectors of society. The government is concerned about its "green benefits", that is, the environmental and social benefits generated; Enterprises are concerned about their "value", that is, the economic benefits generated; Consumers are also concerned about "value", that is, the actual resource and energy savings and comfort generated during operation. Therefore, the benefit evaluation of green building will be helpful to promote the development of green building. Firstly, the empirical study on the economic benefits of green buildings shows that the incremental costs of green buildings vary with different evaluation methods, grades, building types and regions. Different evaluation criteria, its index weight is different, so the emphasis in guiding engineering practice is also different. The different emphasis of engineering practice will directly affect the size of incremental cost. Therefore, for the same building, if different evaluation methods are adopted, its incremental cost will show certain differences [8, 9]. However, no matter what evaluation method is adopted, the incremental cost of green building is positively correlated with its evaluation level. The higher the grade, the higher the requirements on the indicators of construction, so the more input, resulting in the phenomenon that the higher the grade, the greater the incremental cost [10, 11]. The evaluation content of evaluation criteria varies with building types. Compared with public buildings and commercial buildings, the evaluation content of residential buildings is relatively simple. The reason is that it is affected by building functions. Compared with the complex architectural functions of public buildings and commercial buildings, the functions of residential buildings are relatively simple and mainly used for living. Therefore, its incremental cost is much less than that of public buildings and commercial buildings [12]. In order to accurately understand the cost benefit of green building projects and make scientific decisions, most domestic and foreign scholars have established economic benefit evaluation models based on the whole life cycle theory through different methods, such as on the basis of analytic hierarchy process. Combined with the fuzzy comprehensive evaluation method [13], the evaluation model is constructed. It is believed that investors will reduce their investment willingness due to the insignificant economic benefits, but the free choice of investors makes green buildings have real options. Therefore, the real option evaluation method is proposed [14]. Based on the consumer perspective, the incremental cost-benefit is analyzed and the contribution decision model is built [15]. A scenario analysis model is constructed to analyze the evolution path of incremental costs under different scenarios [16]. The economic benefit estimation model was constructed for the green building water-saving project, and the case analysis showed that the model was reasonable [17]. Based on the cost-benefit theory, an economic benefit model is constructed [18]. From the perspective of time, the cost is classified according to the sequence of occurrence, so as to construct the benefit estimation model. The case analysis shows that through effective cost control, the economic benefits of green buildings can be completely improved, so that the initial cost can be recovered within a certain time [19]. The cost estimation model of each star level of green building was established by linear regression method, and the reliability of the model was verified [20]. The key points of cost control are pointed out through the identification of incremental cost [21].

Secondly, domestic and foreign scholars have carried out in-depth research on energy-saving design and energy consumption evaluation of green buildings. Literature [22] points out that the government can promote the development of green buildings by formulating sound incentive measures, strengthening publicity and promotion. Through the analysis of the influence of building energy consumption, it is concluded that the orientation and window-wall ratio have great influence on building energy consumption. Literature [23] simulated the building energy consumption after roof greening and believed that the indoor temperature and energy consumption of roof greening were largely affected by roof greening. In order to improve the energy-saving effect of buildings, roof greening construction should be strengthened. Apriori algorithm, as a traditional data mining method, has been widely used by scholars in various fields. The Apriori algorithm is applied to analyze the defect correlation of power communication equipment [24]. The Apriori algorithm is used to analyze the correlation between the quality factors of prefabricated buildings. The Apriori algorithm can not only analyze the factors that affect things, but also deeply explore whether there is correlation among the influencing factors [25]. By combining genetic algorithm with building simulation software and aiming at minimum building energy consumption and minimum construction cost, an optimization design model is constructed, which can provide multiple sets of optimization design schemes of building designers [26]. The heat transfer coefficient and geometric size of the building envelope were taken as optimization variables, and the optimization targets were set as building heat consumption and building envelope construction investment, so as to establish the corresponding multi-factor optimization mathematical model, and finally achieve the purpose of optimal energy-saving design of building envelope under different conditions [27]. On the basis of comprehensive consideration of economy and comfort, data are collected and processed to establish a bidirectional model of optimization problem, so as to provide indoor thermal comfort conditions in the selection of optimization scheme of HVAC (Heating Ventilation Air

Conditioning) system [28]. It is suggested to use artificial neural network method to predict building energy consumption and, and use genetic algorithm to optimize the connection weight of neural network, building energy consumption and indoor thermal comfort GA-BP network model [29]. Finally, the predictive response surface method and genetic optimization algorithm were established to design the simulation conditions, and the response surface analysis and multi-factor optimization of indoor air quality were carried out on the simulation results. It was concluded that the ventilation mode of lower side air supply and top air return was more favorable for comfort and energy saving when only the influence of supply outlet location, return air outlet location and supply air temperature were considered [30]. Combining computational fluid dynamics and eigen orthogonal decomposition model reduction technique, a new building thermal environment modeling method is proposed which can meet both the accuracy and real-time requirements of thermal environment modeling [31].

From the perspective of genetic algorithm for green building energy consumption analysis and design, the shortcomings of existing studies can be attributed to two reasons: the lack of a perfect building energy consumption information database and energy consumption information model suitable for a single building. From the point of view of machine learning building energy conservation design, existing databases are not developed specifically for data-driven building energy analysis and design. In terms of the mechanism and law of collecting building data, a mechanism that can share data should be designed. It is also necessary to design a standard for the collection of building energy consumption information, so that the data collected in different regions and countries can be integrated to help expand the database and analyze the energy consumption of different buildings. At present, there are many shortcomings in the study of environmental performance of green buildings, which seriously hinder the implementation of relevant technology, means and policies of sustainable development of buildings. Therefore, adopting scientific quantitative methods, improving the objectivity of the research, expanding the scope of the research, establishing a unified evaluation form, reducing the complexity and cost of use, and strengthening the function of the system are the main direction of the development of the research on building environmental performance.

3 ANALYSIS OF INFLUENCING FACTORS OF GREEN BUILDING ENERGY CONSUMPTION

3.1 Analysis of Influencing Factors of Green Building Industrialization

The influencing factors of green building energy consumption can be divided into internal causes and external causes. The external cause refers to the amount of disturbance affecting the indoor thermal environment, which is divided into internal disturbance and external disturbance. Internal disturbance refers to the heating of human body and apparatus in the room, the heat dissipation of the room and the removal of humidity. The characteristics of balanced collocation and neat comparability of orthogonal tables make orthogonal test method have many advantages, such as reducing simulation times and improving the accuracy of analysis results. Therefore, this paper uses orthogonal table to arrange the simulation test. At present, there are many common orthogonal tables summarized by relevant staff in some books of other staff. In the orthogonal experiment, the factors that need to be investigated are called factors, and each factor is divided into several levels. At this time, the levels are called levels, and the numbers "0 "and" 1 "are used to represent them. According to the content described above, this paper will select 7 factors to analyze the energy consumption of buildings, which are: building orientation, shading, window type, roof type, wall type, window-wall ratio and air conditioning system. In addition, the sample factor indicators are classified into three first-level indicators, namely, building planning, envelope structure and energy using equipment. The classification and labels are shown in Tab. 1.

Table 1 First-level indicators and second-level indicators of influencing factors of green building energy consumption

First-order index	Secondary index
S Architectural Planning	S_1 building age, S_2 building type, S_3 building orientation, S_4 building floor number, S_5 building area, S_6 building height, S_7 window-wall ratio, S_8 body shape coefficient, S_9 renewable utilization rate, S_{10} green rate, S_{11} energy-saving policy, S_{12} personnel density
B Enclosure structure	B_1 building structure form, B_2 exterior wall heat transfer coefficient, B_3 exterior window heat transfer coefficient, B_4 roof heat transfer coefficient, B_5 exterior window shading coefficient
C Energy-using equipment	C_1 air conditioning system, C_2 lighting system, C_3 power system, C_4 heating system, C_5 elevator system, C_6 building running time, C_7 variable air volume system, C_8 pipe network system

Building heat consumption can be calculated as follows:

$$q_H = \frac{\sum_{i=1}^{n} \varepsilon_i B_i S_6 S_4}{S_5} + \frac{\sum_{i=1...m} C_i}{S_5} \quad (1)$$

where ε_i is the correction factor of shape coefficient.

The key factors were screened by genetic algorithm, and eight energy consumption factors were defined as X_1 to X_8, namely, exterior wall heat transfer coefficient, roof heat transfer coefficient, body shape coefficient, exterior window shading coefficient, window-wall ratio, personnel density, energy-saving policy and greening rate. In addition to the energy-saving policy using dummy variables, other variables can be obtained directly or through calculation to obtain data. Energy consumption is selected as the explained variable, which is represented by the letter *T*. In the process of building the model, u is a random disturbance term. By logarithmic transformation of the above explanatory variables, the support degree, confidence degree and frequent item set of influencing factors of green building energy consumption can be obtained as follows:

Support degree: $$SupX \to Y = \frac{Cou(X_i \cup Y_i)}{m} \quad (2)$$

Confidence level: $$ConX \to Y = \frac{SupX \to Y}{Sup(X)} \quad (3)$$

Frequent item set: $$\frac{CouX}{m} \geq S_{\min} \quad (4)$$

Eq. (4) indicates that the support degree of item set X of transaction item is greater than the set minimum support degree, which is called $B(X)$ frequent item set.

In this paper, the incremental benefit and incremental cost of energy-saving projects are analyzed quantitatively, and the objective function is constructed. By optimizing the model and adopting genetic algorithm, the optimal solution domain of the project is found and the optimal energy-saving scheme is selected. The construction process of the optimal scheme is shown in Fig. 1.

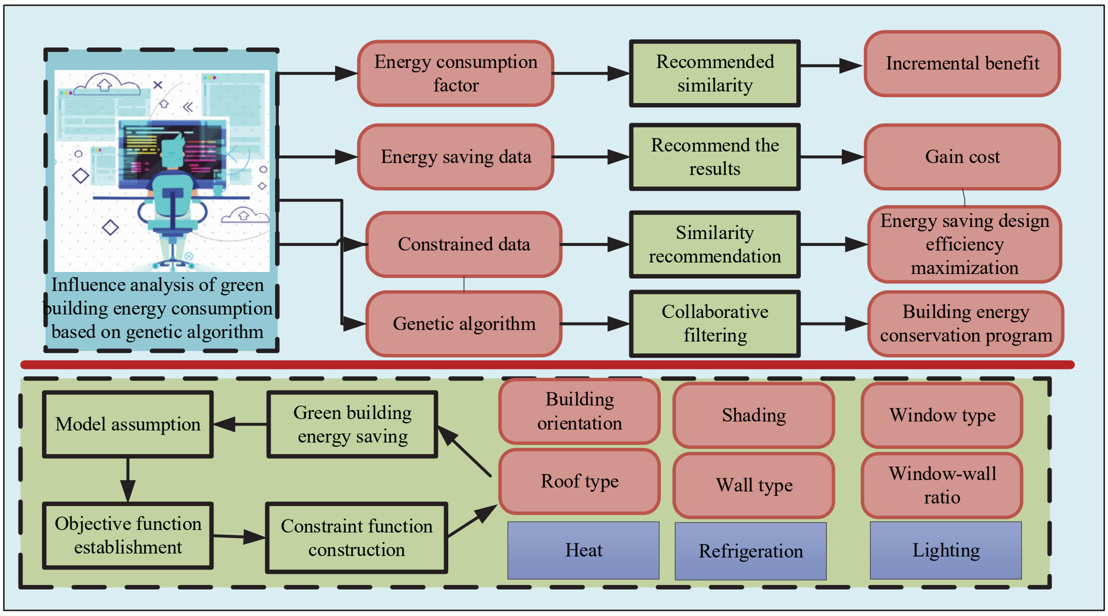

Figure 1 Architecture diagram of green building energy consumption impact analysis based on genetic algorithm

The maximum incremental benefit refers to the energy saving (electricity saving) of the design scheme compared to the benchmark scheme, including the direct economic benefits generated by electricity saving, the environmental benefits brought by emission reduction, and the social benefits brought by reducing electricity investment and power shortage losses. The minimum incremental cost is to carry out a comparative analysis of whether there is no incremental cost, including the initial decision and construction process of the consulting cost and technology cost. Energy-saving design efficiency is the incremental benefit generated by unit incremental cost, and the scheme with high obtained value.

3.2 Improvement of Genetic Algorithm Model for Energy Consumption in Green Buildings

In this paper, energy saving input and energy saving effect are considered comprehensively. By quantifying the two aspects, two factors are established: minimizing the input and maximizing the energy saving effect. Through the construction of the optimized genetic algorithm model hypothesis, objective function and constraint function, the energy saving optimization model is formed, and the genetic algorithm is used to solve the problem. That is, the incremental benefit maximization of unit incremental cost is taken as the evaluation index of the solution domain of objective function to obtain the optimal energy-saving scheme.

Assumptions: (1) When making investment decisions, developers should give priority to the comprehensive benefits of the whole society based on the perspective of the whole life cycle of green buildings, including consumer energy saving, pollutant emission reduction, and social power generation comprehensive benefits. (2) The property is owned by the developer. In order to facilitate the calculation of cost and profit, the operation and maintenance cost generated after the completion of the project will be borne by the developer himself. This paper chooses two parts: exterior window and roof energy saving.

Maximum incremental benefit: the energy saving of energy-saving schemes under each energy-saving technology is summarized to obtain the energy saving (electricity saving) of each year, thus obtaining the annual incremental benefit; Discount the incremental benefit of each year to get the present value of the incremental benefit.

$$S = \sum_{i}^{m} \sum_{j}^{n} \Delta S_{ij} x_{ij} [\delta \times \varphi + P] \times \Delta S_n \quad (5)$$

where, S is the incremental benefit during the calculation period, namely the energy-saving economic benefit, environmental benefit and social benefit, x is the energy-saving scheme, and P is the consulting cost during the decision-making period.

When optimizing genetic algorithm, it is usually expressed by objective function or transformation function of objective function. Individuals are screened by a fitness function, in the same way that selection is done in nature.

The more adaptable individuals are, the more likely they are to be retained. The design of fitness function β requires as simple as possible as the principle, reduce the complexity of calculation in time and space, easy to calculate. And to reflect the degree of the merits of the solution, usually maximization or minimization, single value, non-negative and other functions not difficult to understand and easy to implement. The following model is constructed:

$$Y=\beta_0+\beta_1 X_1+\beta_2 X_2+\ldots\beta_8 X_8+u \tag{6}$$

The steps to realize the influence of genetic algorithm on energy consumption of green building

(1) Coding

Encoding according to the code number system type is mainly divided into binary encoding and decimal encoding, binary encoding format neat, easy to understand; but decimal coding is easy to observe and does not require number system conversion, so decimal number coding is used.

(2) Decoding

The gene is multiplied by the decoder to convert the gene into the actual value. For the encoding in the above example, the decoder selection is as follows:

$$\frac{b-1}{n}[10^x,10^{x-1}\ldots 10^1,10^0]^T \tag{7}$$

(3) Cross

$$\int(g_x^1,g_{x-1}^1\ldots g_1^1) \tag{8}$$

For the population of any generation, the average fitness and maximum fitness of the population are calculated first, and an adaptive index is constructed through −. When judging any individual, calculate the fitness β of the individual, through the formula:

$$(g_1(f_{\max}\geq\beta)/f_{\max})\geq\overline{f} \tag{9}$$

(4) Calculate fitness. Through fitness calculation, the individual population is evaluated to determine whether it is optimal. Based on the results of fitness evaluation, the next generation of new individuals is generated. Crossover and mutation operation to produce new individuals; calculate, evaluate and judge the fitness of the newly generated individuals. The flow chart is shown in Fig. 2:

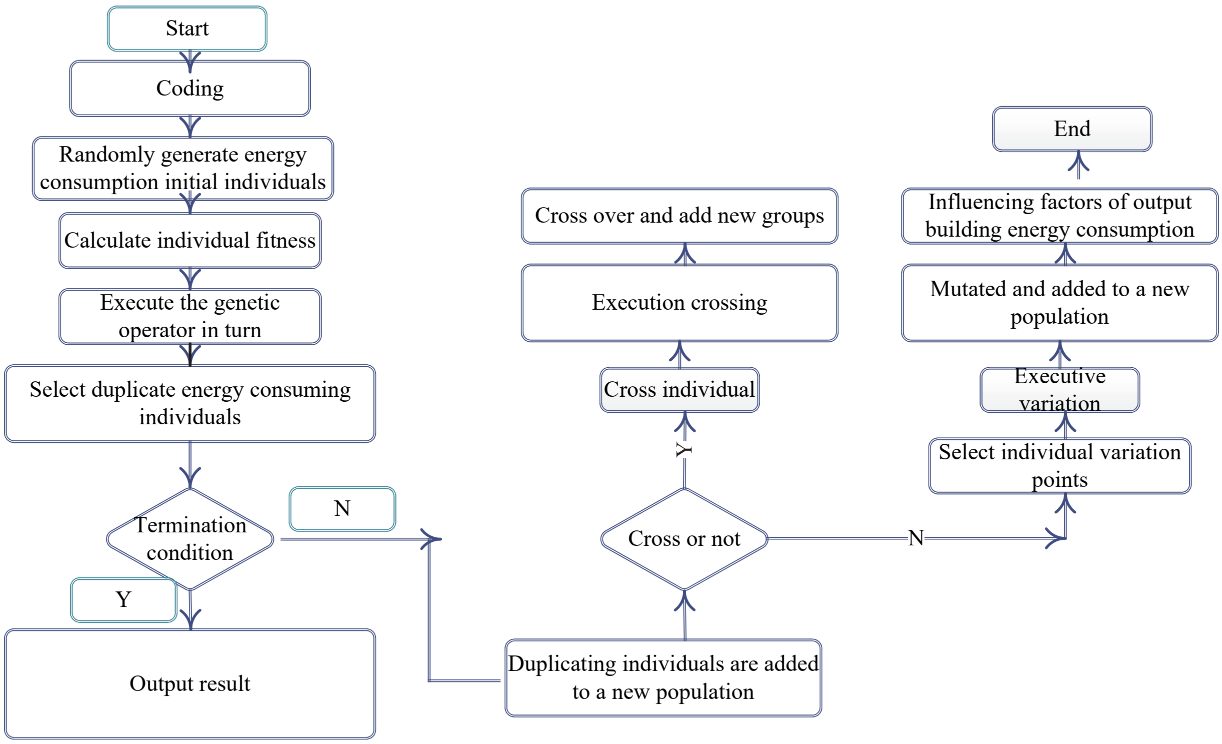

Figure 2 Flow chart of green building energy consumption impact assessment based on genetic algorithm

First of all, coding is divided into binary coding and decimal coding according to different code number system types. The binary coding format is neat. Secondly, decoding and crossover are carried out. Genes can be converted into actual values by multiplying the gene by the decoder. The crossover is to calculate the average fitness and maximum fitness of the population first. Finally, the population individual is evaluated through fitness calculation to determine whether it is optimal. Based on the results of fitness evaluation, selection is made to generate the next generation of new individuals.

3.3 Parameter Selection and Index Analysis of Green Building Energy Consumption

When evaluating the energy consumption of green buildings, if only the building area is considered without considering the running time, the energy utilization efficiency of buildings with short running time will become higher, which is not conducive to finding the real factors affecting the building energy consumption. At present, optimization parameters focus on building envelope structure, such as building orientation, window wall ratio, insulation layer thickness, glass type, and less consider the air-conditioning equipment system parameters. The parameters of equipment operation are introduced, and indoor environment comfort is taken into account. A simple influencing factor of heating and air conditioning system is added into this optimization model: indoor temperature control point, which is a preliminary exploration. Parameters selected in this optimization design: building orientation (wo), window-wall ratio (wwR), shading coefficient (SC), heating temperature setting point (HTP), air conditioning temperature setting point (CTP), exterior wall enclosure structure (WS), roof enclosure structure (RS) and glass type (GT) are the main optimization objects, among which there are 3 discrete variables. There are 5 continuous variables. See Tab. 2 for the specific values of each optimization parameter.

Table 2 Parameter variables and specific values

Parameter name	Variable type	value
Building Orientation (WO)	Continuous type	[173, 325] [11%, 92%] [0.15, 0.85] [15, 22] [22, 26]
Window-wall ratio (WWR)	Discrete type (8 categories)	G1 Sgl-Clr 2 mm G2 Sgl-Clr 5 mm G3 Sgl-LoECIr 2 mm G4 Sgl-LoECIr 4 mm GS Dbl-Clr 2 mm/14 mm Air G6 Dbl-Clr 2 mm/12 mm Air G7 Dbl-LoECIr 2 mm/1 2mm Air G8 Dbl-LoECIr 4 mm/12 mm Air
Shading coefficient (SF)	Discrete type (9 categories)	*X*1 12 mm exterior Tile + 11 mm EP S board + 22 cm concrete brick + Plaster finish *X*2 15 mm exterior Wall Tile + 25mmEPS board + 25 cm concrete brick + Plaster plaster finish *X*3 15 mm exterior Tile + 35 mm EPS board + 25 cm concrete brick + Plaster plaster finish *X*4 15 mm Exterior Tile + 45 mm EPS board + 25 cm concrete brick + Plaster finish *X*5 15 mm Exterior Wall Tile + 55 mm EPS board + 25 cm concrete brick + Plaster Plaster finish *X*6 15 mm Exterior Wall Tile + 65 mm EPS board + 25 cm concrete brick + Plaster Plaster finish *X*7 15 mm Exterior Wall Tile + 75 mm EPS board + 25 cm concrete brick + Plaster Plaster finish *X*8 15 mm Exterior Tile + 85 mm EPS board + 25 cm concrete brick + Plaster finish *X*9 15 mm Exterior Tile + 95 mm EPS board + 25 cm concrete brick + Plaster finish
Heating temperature setting point (HTP)	Discrete type (9 categories)	R1 55 mm light mix + 5 mm waterproof + 15 mm EPS board + 20 cm concrete + 45 cm suspended ceiling R2 55 mm light mix + 5 mm waterproof + 25 mm EPS board + 20 cm concrete + 45 cm suspended ceiling R3 55 mm light mix + 5 mm waterproof + 35 mm EPS board + 20 cm concrete + 45 cm suspended ceiling R4 55 mm light mix + 5 mm waterproof + 45 mm EPS board + 20 cm concrete + 45 cm suspended ceiling R5 55 mm Light mix + 5 mm waterproof + 55 mm EPS board + 20 cm concrete + 45 cm suspended ceiling R6 55 mm light mix + 5 mm waterproof + 65 mm EPS board + 20 cm concrete + 45 cm suspended ceiling R7 55 mm light mix + 5 mm waterproof + 75 mm EPS board + 20 cm concrete + 45 cm suspended ceiling R8 55 mm light mix + 5 mm waterproof + 85 mm EPS board + 20 cm concrete + 45 cm suspended ceiling R9 55 mm light mix + 5 mm waterproof + 95 mm EPS board + 20 cm concrete + 45 cm suspended ceiling

This paper proposes the time-normalized building energy intensity:

$$TNEUI = \frac{EUI}{TI} \tag{10}$$

EUI is the energy consumption per unit area, *TI* is the average daily operation intensity of the building, which can be calculated by the following formula:

$$TI = \frac{\sum_{x}^{n} t_i * d_i}{1440} \tag{11}$$

where t_i represents the number of operating hours per day of type *i*; d_i indicates the number of type *i* days in a year. As shown in Fig. 3, the total energy consumption has the largest discrete type, that is, the running time of the building has the greatest impact on the evaluation of the total energy consumption of the building, followed by heating energy consumption, and finally cooling energy consumption. This may be because many office buildings are central heating and air conditioning systems, whose operation time is centrally controlled, and there will be a phenomenon in office buildings that air conditioning systems continue to be used after closing. It can be seen from the research in this section that running time has a certain impact on the ranking of building energy consumption. If the running time of the building is not considered in the calculation of energy consumption intensity, the running time of the building should be limited to a certain range, so that the calculated results will be more reliable.

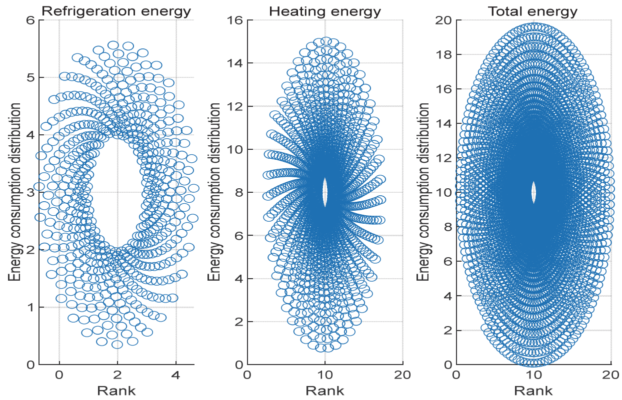

Figure 3 Distribution of building energy intensity ranking before and after considering building running time

4 SIMULATION

Taking an office building as the research object, this paper firstly sets the benchmark scheme and design scheme respectively for the office building. Secondly, through the simulation of green building energy consumption and quota estimation by genetic algorithm, the energy saving and incremental cost of each design scheme compared with the benchmark scheme are obtained. Thirdly, based on the obtained energy saving and incremental cost data, genetic algorithm is used to solve the energy saving optimization model. "Energy-saving design efficiency" is used to select the optimal solution domain, and the optimal scheme of incremental benefit of green building energy saving is obtained. With Eq. (6) as the model, genetic algorithm is used to carry out adaptive analysis of influencing factors of green building energy consumption, and the results are shown in Tab. 3.

Table 3 Analysis results of influencing factors of green building energy consumption

	Adaptive coefficient		
*X*1	0.324	0.834	1.515
*X*2	0.36	0.315	2.539
*X*3	0.67	0.739	6.149
*X*4	−0.71	−0.492	4.255
*X*5	−0.52	1.053	1.541
*X*6	0.71	1.249	2.623
*X*7	−0.66	−0.84	2.315
*X*8	−0.38	−0.265	3.15
Constant term		0.93	
R-square	0.986		
F-square	0.835		

Under the parameters set in Tab. 2, the results after 1000 iterations are shown in Fig. 4, Fig. 5 and Fig. 6.

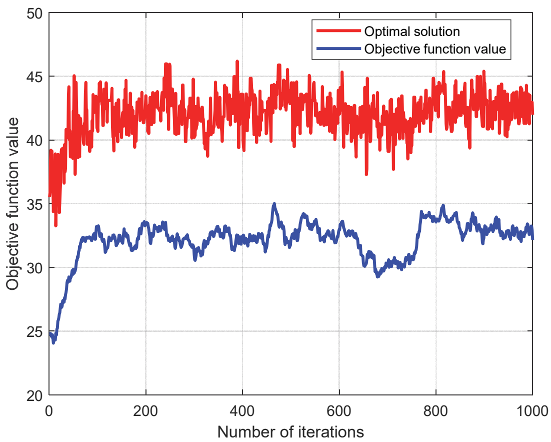

Figure 4 Changes of the mean value of the objective function and the optimal solution after 1000 iterations

As shown in Fig. 4, Fig. 5 and Fig. 6, the result data shows that after 1000 iterations, when *WWR* = 0.4559, the building energy consumption and the cost of the enclosure structure can reach the lowest, and the indoor thermal comfort can reach the best. Thus, it can provide the selection of external wall insulation materials and external window glass type. At this time, the building energy consumption *TI* is 4.1197 W per square meter, which is lower than the previous energy consumption value and reaches a relatively comfortable state.

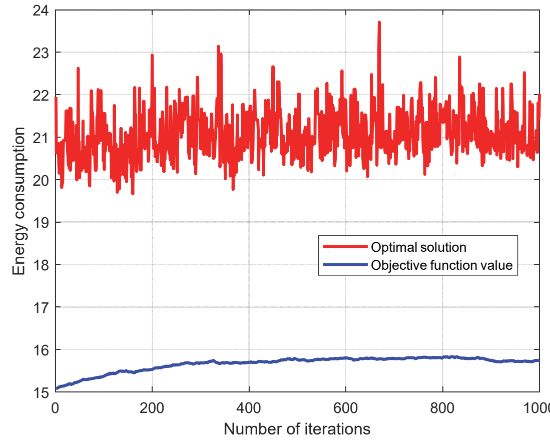

Figure 5 Change of mean energy consumption and reconciliation after 1000 iterations

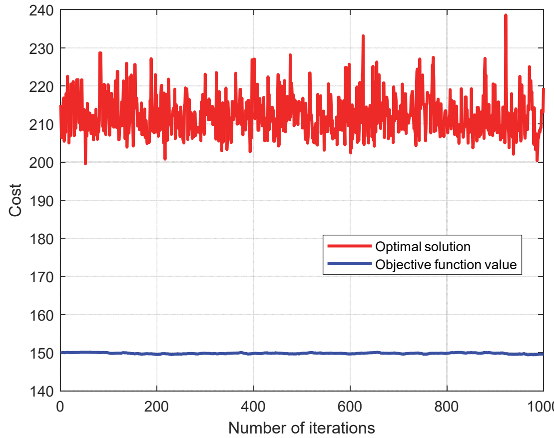

Figure 6 Change of mean value of enclosure cost and reconciliation after 1000 iterations

In addition, in order to verify the distribution curve of heating and cooling energy consumption in the factors affecting energy consumption of green buildings, the experimental parameters set in Tab. 2 were verified, as shown in Fig. 7. It can be seen from the figure that the heating and cooling energy consumption in the factors affecting energy consumption of green buildings showed logarithmic distribution.

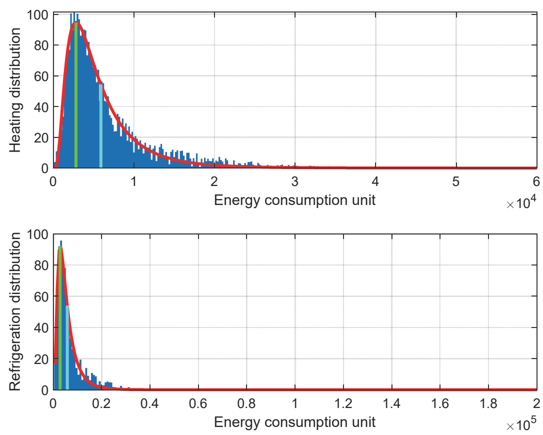

Figure 7 Distribution of energy consumption of cooling and heating in green building

In this paper, the improved genetic algorithm is applied to optimize the calculation of the influencing factors of green building energy consumption. In each optimization calculation, the operating energy consumption of the system adopted in the example converges to the same result: 16.95MMJ, and the corresponding external wall envelope structure scheme is as follows: 15 mm external wall tile + 55 mm EPS board + 25 cm concrete brick + plaster, and the roof envelope structure is as follows: 55 mm light mix + 5 mm waterproof + 55 mm EPS board + 20 cm concrete + 45 cm ceiling, through the database query, it can be known that in the envelope structure scheme, the heat transfer coefficient of various components is the lowest value of similar components, after calculation. In the future, the maximum value of incremental benefit brought by unit incremental cost of this building is 24.8 yuan per square meter, which verifies that the improved genetic algorithm adopted can complete the optimization task proposed in the analysis of the impact of green building energy consumption. Fig. 8 shows the three-dimensional graph of the fitness value of genetic algorithm in the verification process and Fig. 9 shows the maximum - average fitness difference of the fitness value of genetic algorithm in the verification process.

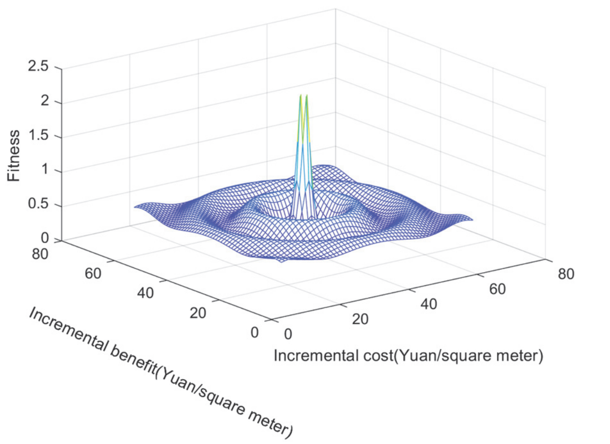

Figure 8 Three-dimensional graph of fitness value of genetic algorithm in verification process

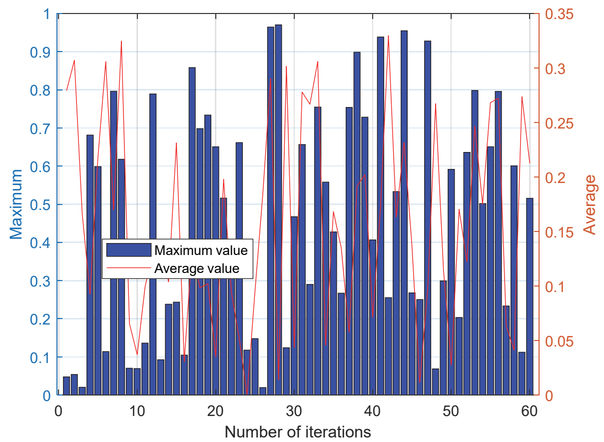

Figure 9 Maximum - average fitness difference of genetic algorithm in the verification process

Among the influencing factors of green building energy consumption based on genetic algorithm, the influence of heating equipment cannot be ignored, as shown in Fig. 10, which shows the distribution of main heating equipment in buildings with high and low cooling performance. The similar distribution of variables in the two charts indicates that primary heating is not the main reason for the difference in energy consumption per unit area of the buildings. Similar buildings here all have a larger cooling demand and a smaller heating demand, so this phenomenon can occur. For buildings with large heating demand before, the main heating is an important parameter.

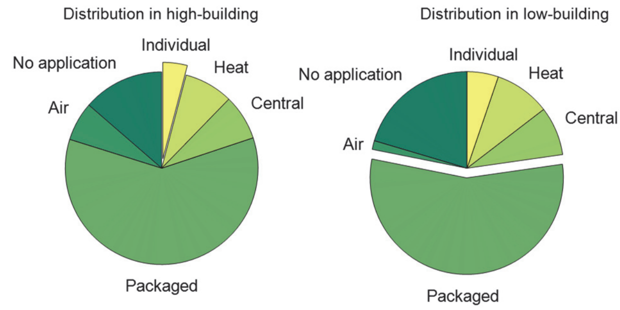

Figure 10 Distribution of main heating equipment in green building performance buildings

Due to the lack of other electricity data such as lighting, the main concern is the building's heating and air conditioning energy consumption. Fig. 11 shows a macro assessment of the building's energy consumption. It can be clearly seen from the figure that the cooling energy consumption of buildings ranks higher in similar buildings, that is to say, the energy consumption is higher and the energy saving potential is higher. The energy consumption of heating is at a medium level, which does not have a high energy saving potential.

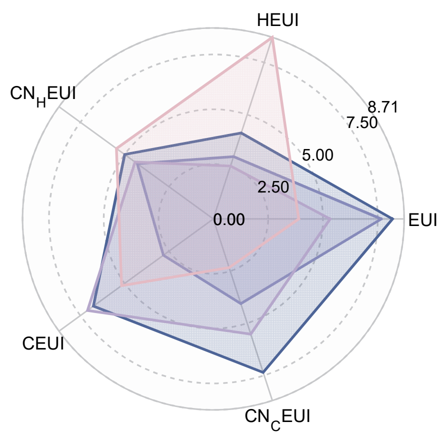

Figure 11 Energy consumption assessment results of green buildings

5 CONCLUSION

Aiming at lighting and energy consumption, this study carried out multi-factor optimization analysis based on genetic algorithm on factors such as windowing ratio, wall heat transfer coefficient, window heat transfer coefficient, window transmittance and roof insulation coefficient. By using the method of computer simulation and theoretical analysis, the optimization analysis of the building scheme is carried out to find the optimal design range of each influencing factor and the optimal design method of green low-energy building. Firstly, a set of relatively perfect building energy consumption information model is proposed, which lays a foundation for collecting a large number of building data and forming building energy consumption information database. Secondly, the theory of multi-factor optimization and the principle of genetic algorithm are summarized, and the heat transfer coefficient of external wall and window of the building is selected as the optimization variable, so as to achieve the goal of lower energy consumption and enclosure cost and better thermal comfort. Finally, the comprehensive benefit composition of green building energy-saving functional projects was established, and a multi factor optimization model was constructed. The genetic algorithm is selected, and the Control variates is used to obtain the incremental cost of energy consumption and quota estimation of each green building energy-saving design scheme. The maximum incremental benefit generated by unit incremental cost is 24.8 yuan per square meter. On the basis of this study, the next step will be to study the functional relationship between building energy consumption and enclosure structure, as well as between thermal comfort and enclosure structure, taking into account enclosure cost, and using genetic algorithms for multi-objective optimization research.

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