Research on Decision Model of Building Energy Efficiency

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Abstract. Following the overall building energy-saving situation in China and reflecting the rationality and flexibility, the paper aims to investigate the decision methods of existing building energy efficiency retrofitting (EBEER) projects under uncertainty to facilitate comprehensive and objective assessment in such projects. In this paper, the internal and external uncertainties affecting energy efficiency are identified and their random fluctuation characteristics are qualified and introduced into the analysis of decisions. By taking into account life-cycle costs, energy savings, carbon emission and thermal comfort, a project revenue optimization model under uncertainty is established to explore the dynamic quantitative relationship between energy-saving technology solutions and the costs and benefits over a long horizon for EBEER projects. By means of optimizing analysis, the multi-stage optimal scales and energy-saving technology solutions for EBEER projects are achieved. This paper will provide a new perspective for solving EBEER projects' and financing fatigue to contribute to the returns and the smooth implementation of EBEER projects in China.

Introduction

The rapid development of Chinese economy brings the increasing demand for energy. Although in China the resources are quite large, but due to the large population radix per capita availability is below the world's average level. Energy bottleneck is a block of the development of China. According to research, building energy consumption that takes the proportion of total energy consumption is alarming. For now most of the old buildings have poor thermal insulation structure and building air tightness which consume high energy. [1] So it is important to develop new technology and proposal to keep sustainable development. In order to maximize the profits of energy-saving renovation, it is important to evaluate the decision making method of energy saving project. [2] In the decision of architecture energy saving program, there are lots of factors to consider about. How to sum up all kinds of factors in scientific ways becomes the key point to make right choice. [3] The key point of existing building energy saving is to reconstruct the maintenance of structure, the roof or the facilities inside. [4] It is hard to choose the right methods to make the best profits. The comprehensive evaluation system was built to find the existing risk in the project and guide the project decision-makers to avoid risks, and also to evaluate the effect of the energy-saving renovation.

Building energy consumption data analysis methods and energy control strategies are the focus of this study. [5] Building energy consumption data analysis can help us to grasp the actual situation of Building energy consumption, analyze the features of building energy, investigate the basic causes of building energy consumption changes, and finally find the potential of building energy efficiency. Study of energy consumption control strategy is conducive to the building reforming plan of energy saving and the determination of the focus or the direction of building city or zone, which then can achieve the scientific decision of building energy management. [6] This research can also provide strong support for the development of the relevant policies and regulations, which means the important theoretical significance and application worth. The structure of light container is shown in Fig. 1.

Fig. 1 The structure of light container

The following achievements have been accomplished in this paper.

The scientific classification of building and building energy consumption has been offered, and the regional building energy model based on statistical data has also been built. This classification can change the study of building energy consumption into the analysis of the distribution rules with different building types and their corresponding building areas. Based on the different study objects, building energy analysis can be divided into three levels. First, it is the research of single building energy consumption, which can give support for the evaluation of the energy-saving operation and the choice of the specific energy reforming methods. Second is the energy analysis of same kind of buildings. The characteristics and the basic laws of a certain type of building energy consumption can be studied, which can be used to assess the effect of energy management and the operation performance of buildings with different types. Third, it is the statistical analyses of the building energy data on the level of zones, which can determine the focus of building energy policy and give strong support to the formulation of the related laws and rules. Based on the existing database of Wuhan city, the building energy of Wuhan has been studied by the regional building energy model, and then come to the conclusion that civil building energy consumption of Wuhan town in 2009 is about 19.17 million tons of standard coal. (Eq. (1))

$$\Delta E = E_{pre} - E_{pro} = \sum_{i=1}^{5} \sum_{j=1}^{n_i} E_j X_j \tag{1}$$

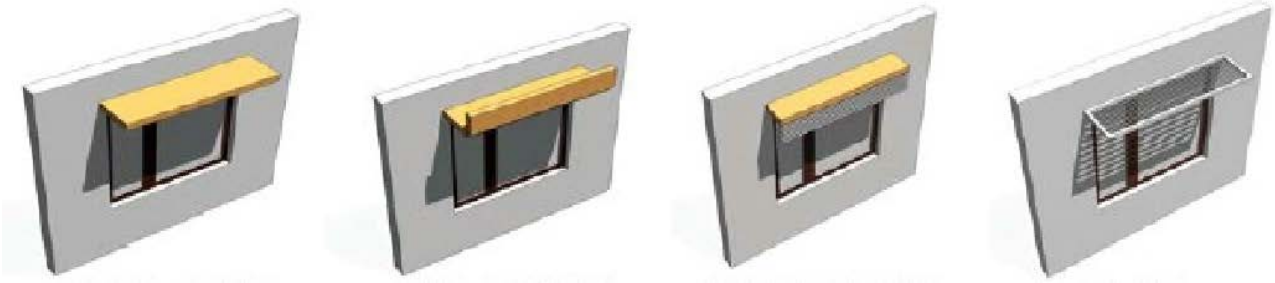

Fig. 2 Extension of the sun visor

Extension of the sun visor is shown in Fig. 2. The improvement method of building energy statistics is proposed. For the present, many factors such as the different boundary definition, the different energy conversion methods, the different energy measurement methods or instruments, and the professional background for the Statisticians with different training levels, will affect the quality of the statistical data, then can cause the data distortion. First, the pretreatment method before analysis can effectively reduce the data distortion. After that the data analysis and the calculation results can be more accurate with the improvement of the statistical system and standards, the data analysis method, and the appropriate incensement of the sample number. (Eq. (2)) Besides the choice of the values of the local energy conversion coefficients can also get different calculation results,

which can even have the important role on the direction for the government policy and the comprehensive utilization of energy. (Eq. (3))

$$\Delta V = V_{pre} - V_{pro} = \sum_{i=1}^{5} \sum_{j=1}^{n_i} V_j X_j \tag{2}$$

$$C = C_0 + C_{M\&O} = C_0 + \sum_{i=1}^{5} \sum_{j=1}^{n_i} C_j X_j \tag{3}$$

Based on the analysis on the technology of building energy and energy data, building energy control determination model is built, which is used to do the analysis of the different building energy schemes for Wuhan. On the basis of a great quantity of investigation and test analysis, the technology of building energy saving is evaluated objectively. Most of the influential factors for building energy, including the economic development, population change, construction area of growth, comfort requirements, electrical equipment and others, will be analyzed synthetically. The feasibility and economy of the frequently-used energy control methods, such as the energy-saving reforming methods of building envelope, the energy saving technology of heating system and renewable energy system, the metering of building energy, the people behavior of energy saving, etc.， will also be discussed. The studied results show that the comprehensive transformation of the old and non-energy saving buildings have very large influence on the building energy consumption of Wuhan. The low-cost transformation of commercial building, the technical level of gas, coal-fired heating system have to be the key point for the management work of energy saving. (Eq. (4))

$$\begin{cases} \max\ \Delta E(X) \\ \max\ \Delta V(X) \\ \min\ C_0 + C_{M\&O}(X) \\ \min\ \Delta PMV(X) \end{cases} \tag{4}$$

$$s.t.$$

$$X_{ij} \in \{0,1\}, i = 1,2,3,4,5; j = 1,2,3,...n_i$$

Fig. 3 The effect of several kinds of awnings

The effect of several kinds of awnings is shown in Fig. 3. A comprehensive study of Wuhan building energy management system and operation mechanism will be finished with the discussion about many kinds of factors which include the advantages and disadvantages of the existing system, the study of the formulation about regulations and standards, the policy incentives, the energy saving assessment methods, and the framework of supervision and management. Several key problems of the whole frame and guidance of the work for building energy saving will be resolved consequently.

The calculation results are shown in Table 1.

Table 1 The calculation results

Numble	F	The best route	K
4(1)	210	4(1)-5(2)-6(1)	K5(2)
4(2)	200	4(2)-5(2)-6(1)	K5(2)
4(3)	250	4(3)-5(2)-6(1)	K5(2)
3(1)	1350	3(1)-4(3)-5(2)-6(1)	K4(3)
3(2)	1250	3(2)-4(3)-5(2)-6(1)	K4(3)
2(1)	1300	2(1)-3(2)-4(3)-5(2)-6(1)	K3(2)
2(2)	1370	2(2)-3(2)-4(3)-5(2)-6(1)	K3(2)
1	1350	1-2(1)-3(2)-4(3)-5(2)-6(1)	K2(1)

Summary

This paper is based on different literatures and using a combination of qualitative and quantitative analysis. This paper introduces the building energy-saving technology around the world. The most suitable ways should be chose according to actual situation. With systematically summarizes new technology of energy-saving project combined with different climate in all regions of China, this paper also complete a suitability analysis of existing energy-saving project. By using value engineering methods to estimate all factors in the proportion of the program precisely Decision makers could calculate value coefficient and chose the best policy to make the biggest profit. Through value engineering evaluation method, decision makers can evaluate comprehensive factors of the project. To determine the weight of each index by hierarchical model, this paper introduced the theory of fuzzy mathematics, fuzzy comprehensive evaluation model as the enclosure structure energy saving evaluation tool. It shows the way that how value engineering works to estimate all factors in the proportion of the program precisely，by getting cost coefficient and function coefficient, Decision makers could calculate value coefficient and chose the best policy to make the biggest profit. By example of a library in Chongqing, the results reflect actual problems of project and points out risks in energy saving project which verify the rationality and applicability of the model.

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