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Research on Investment Decision of Green Public Building Based on Analytic Hierarchy Process and Fussy Evaluation

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Abstract: In this paper, with China's economic and social development, energy shortage and environmental deterioration has become an acute problem. The promotion of green public building, palys a veryimportant role for building a resource-conserving and environment-friendly society in China. This paper analysis on the connotation of value engineering and green public building, demonstrates the value engineering to the necessity of investment decision of green public building, and describes its application process. In particular, the environmental benefits, the individual benefits, social benefits are as a function of green public building, use the analytic hierarchy process and fuzzy comprehensive evaluation to quantitative analysis each function index, ultimately use value engineering to make investment decisions for green public building.

Keywords: Analytic hierarchy process, fussy evaluation, green public building, investment decision.

1. INTRODUCTION

Since 2014, large public buildings will be the first implementation of green building standards. Since 2014, government investment in government agencies, schools, hospitals, museums, science museums, stadiums and other buildings, municipalities, separately listed cities and the capital city of the construction of affordable housing, as well as single building area of over 20,000 square meters airports, railway stations, hotels, restaurants, shopping malls, office buildings and other large public buildings, will be the first implementation of green building standards. Thus, green public buildings has risen to a national strategy [1-3]. The value engineering applied to the investment decisions of green public buildings, public buildings for people to contribute to strengthening the awareness of green, while providing assistance for the development of green public buildings.

2. GREEN PUBLIC BUILDINGS

In recent years, as the economy continues to develop, increasing investment in fixed assets, China has become the building big country. Government to people's lives, local economic development has brought great impact on investment in the construction of public buildings. The rise buildings also gave rise to a comfortable life, but also brings a high energy consumption, high pollution and other issues. Energy conservation is an arduous and long-term task. Has a wide range of public buildings, quantity, and more from the government and other characteristics, public buildings and therefore has great potential in terms of energy conservation [5].

Combined with the concept of green buildings and public buildings, in this paper, the definition of green public buildings as follows: On the basis of the traditional public buildings, based on the green building concept into the whole life cycle of the building, from the energy, materials, water conservation, environmental protection and adhere to the principles of sustainable development, starting at the same time to meet the people's needs, and the natural and social architectural harmony [6]. Green public buildings in public buildings full life cycle stages, through scientific overall design, combined with green configuration, natural ventilation and lighting, low energy consumption and maintenance methods, and the use of new energy, water reuse, green building materials and other high-tech high intelligence technology, thereby building to meet the functional needs of the people, while the most reasonable resource consumption, minimal environmental impact buildings [7, 8].

2.1. Externalities of Green Public Buildings

The main economic activity in an economy which gives the community bring additional economic benefits to other economic actors, but its own cannot be compensated, this property is called "positive externalities." When the construction of the main use of the concept of green building development and construction, can reduce the waste of resources, air pollution, improve the local ecological environment, at same time promote local economic development. But in the market mechanism of environmental, social did not pay the appropriate remuneration for the construction of the main green building, therefore green building has a positive externality. This is just the "public" in public buildings. Therefore, positive externalities for green public buildings brought great social benefits.

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2.2. The Problems of Green Public Building Research

(1) Green's study of public buildings is still in its infancy. Green building concept was proposed in recent years. For evaluation of green public buildings there is no uniform standard [9].

(2) Public construction projects are mostly large projects, covers, material consumption, capital spending is very large, there is a problem of high energy consumption and high pollution, has a great impact on the local resources and the environment, the green concept throughout the project has some difficulties.

(3) Most public buildings and government investment in the development and construction management. So people did not pay enough attention to high energy consumption in public buildings, resulting in energy conservation in public buildings has been falling at a low rate of implementation less than real, and greenness.

(4) Public buildings are mostly integrated projects. To reach the green requirements, the relevant departments need to participate in consultation and co-operation. But for now, all departments miscommunication, with a low degree, to be further improved [11].

(5) For the "green" one-sided understanding. Green building is not a one-sided public green area from the expansion and increase green ornaments. But in the whole life of the project, through scientific and rational approach to the green concept through design and development to post-maintenance process.

(6) Because of the positive externalities of green public buildings, public buildings, so the green can bring great social benefits. But the size of the social benefits, it is difficult to use a specific formula to calculate the figures. It has a great influence on the investment decisions of green public buildings.

3. VALUE ENGINEERING IN GREEN BUILDINGS

3.1. Value Engineering Principle

Value Engineering, also known as value analysis, for the purpose of enhance the value of goods or services, is a management technique in the whole life cycle of a product or service, through organized creative work, with the lowest life cycle cost, and product or service important functions. The "value" of Value Engineering means the ratio between features of a product or service and the full cost to get this feature to pay. Mathematical formula can be expressed as:

$$Value = \frac{Function}{\mathrm{Cos}\,t} \tag{1}$$

Of which, Function is the study of the function, Cost is the entire life-cycle costs. Consider the value of value engineering major departure from the consumer point of view, rather than producers' subjective imagination. Value engineering is a core product or service functional analysis, basic functions and auxiliary functions accurately distinguish clearly the relationship between the various functions, to determine the value to select the best option.

3.2. The Necessity of Apply Value Engineering to Green Public Buildings

Different from the traditional public buildings, the most important characteristic of green public buildings, from building a full life cycle starting with the lowest life-cycle cost of the construction to meet the needs of the people of functional buildings. The essence of this is precisely coincide with the value engineering. Therefore, the value of the project will be applied to investment decisions in public buildings, in favor of building a conservation-oriented society to achieve national goals.

First, the meaning of green public buildings and value engineering is the same. Value engineering is the process to identify problems, analyze problems and problem-solving. Green public buildings is seeking public buildings energy-saving and emission reduction of the site, analysis of energy conservation methods, and, ultimately, public buildings green requirements. Value engineering is at the lowest cost to achieve maximum value function. Green public buildings is the lowest life-cycle costs, people for public buildings "green" requirement. So the two are the same.

Second, the value of the project for the investment decisions of green public buildings have a very significant impact. Public buildings with a large investment, ongoing maintenance costs and more and more investment by the state and so on. Most public buildings larger upfront investment. People tend to pay attention to the construction costs, while ignoring the building in the course of maintenance, operation and management costs. Compared to construction costs, ongoing maintenance is not a one-time expenditure spending is spending a long and continuous, but most of these costs paid by the government. The green public buildings although the higher upfront investment, but to make use of significantly reducing the cost of late. Therefore the value engineering applied to investment decisions among green public buildings, from the whole life cycle of construction projects, investment decisions to the early to the late operation and maintenance as a whole is considered, which can help the government make decisions to achieve public buildings "green "the goal.

Finally, outside of green public buildings, so that building green public buildings can bring great social benefits. Many public buildings are the focus of the project countries, and has a long and far-reaching effects, mostly to highlight the image of the country or region of landmarks. Value engineering goal is to minimize the resource consumption for maximum value, so the use of value engineering can improve the economic efficiency of the whole society. While social benefits is a relatively abstract concept, it is difficult to measure the specific value. Value engineering for green public buildings can function value analysis, calculated relative to the size of specific social value.

4. ANALYTIC HIERARCHY PROCESS AND FUZZY SYNTHETIC EVALUATION MODEL

4.1. Analytic Hierarchy Process

Generally known as Analytic Hierarchy Process, is a multi-factor invented by Strategy Professor Thomas L. Satty University of Pittsburgh in the 1960s. Analysis hierarchy

process, the complex multi-factor decision problem is decomposed into multiple levels of sub-factors on the mutual comparison and weight calculation problems in a more intuitive way possible to achieve multiple choice and merit the sort that might be taken. Analysis hierarchy process approach is flexible, adaptable, and can be used to compare the qualitative and quantitative indicators mixed, and the comparison can be used in combination with other methods such as linear programming, etc. [2] as well as multi-merger from experts and stakeholders subjective opinion. Thus it is widely used in system design, contractor selection, resource allocation and other application areas.

Analytic Hierarchy Process generally has the following five steps:

(1) Target recognition decisions, evaluation principles and options: to purchase a computer system, for example, decision-making goal might be "the best computer system for video content production." Evaluation principles, including hardware, software, and economic aspects of three. Option is a system of three different suppliers.

(2) Evaluation principles stratified to get hierarchy of problems: the goal is the highest level of decision-making, evaluation principles for the middle level, options on the bottom. Evaluation principles can be further stratified according to the center needs. Evaluation principles such as hardware, including display devices, storage devices, the central processor performance, they can be placed under evaluation principles "hardware" level.

(3) Pairwise comparison of each element within each level, starting from the lowest level of evaluation principles. For example, in this display device hardware level evaluation principles under the pairwise comparison of the extent of the merits of the three computers to obtain comparative 3x3 matrix P. In general, the n m different evaluation principles and selection systems, the need to obtain a total of n of size m * m matrix. The element P_{ik} of such a comparison matrix $P_j, j \in (1,2,3,...,m)$ has the following properties:

$P_{ik} \in 9, 8, 7..., 2, 1, 1/2, 1/3, ..., 1/8, 1/9$ c

$P_{ik}=1$ when $i = k$

$P_{ik}=1 / P_{ik}$

(4) The result of comparison: the comparison matrix for standardization. Each element in the matrix, it is divided by the sum of all elements and the column; matrix normalized eigenvectors, and calculate the consistency ratio.

(5) The combined result of the comparison and draw decisions.

4.2. Fuzzy Synthetic Evaluation Model

Fuzzy comprehensive evaluation method is the application of fuzzy mathematics broader method. In the evaluation of a transaction often encounter this kind of problem. Because evaluation of the transaction is determined by many factors, and therefore must be evaluated for each factor; Make a separate comment for each factor on the basis of how to consider all factors and make a comprehensive comment. This is a comprehensive evaluation.

For the decision problem of green public buildings, and its influencing factors of great complexity. Exact cause of reducing the ability of the system described in the fuzziness. Using fuzzy means to deal with the ambiguity of the problem, it will make the evaluation results more real, more reasonable. Fuzzy comprehensive evaluation model to go through the following steps:

(1) Given alternative set of objects: Here is the all green public buildings;

(2) Determine the index set;

(3) Establish weight set: As important indicators of the degree of centralization of each index are different, so be on the level indicators and secondary indicators were given corresponding weights. The first level of the weight set is $A(a_1, a_2, ..., a_n)$, and the second level of the weight set is $A(a_{i1}, a_{i2}, ..., a_{ij})(i \quad 1, 2, ...,)n$. Here use factor analysis to determine the right number;

(4) Determine reviews set $v = (v_1, v_2, ..., v_m)$. We put evaluation set to v = {safety, general, dangerous};

(5) Identify the evaluation matrix $R = (r_{ij} v)_{n \times m}$. First determine the membership function U for v, and then calculate the stock evaluation for each class of membership r_{ij} ;

(6) Obtained fuzzy comprehensive evaluation set $B = AoA : (b_1, b_2, ..., b_m)$, namely ordinary matrix multiplication. According to the final results of the evaluation judgment was set.

5. INVESTMENT DECISION REALIZATION

5.1. Determining Method for Qualitative Index Membership Degree

Evaluation object set is P: its factor set is $U = (u_1, u_2, ..., u_m)$, its evaluation rating set is $v = (v_1, v_2, ..., v_m)$. In U for each factor, according to the level of concentration of the fuzzy evaluation index evaluation, obtain evaluation matrix:

$$R == \begin{pmatrix} r_{11} & r_{12} & ... & r_{1m} \\ r_{21} & r_{22} & ... & r_{2m} \\ r_{31} & r_{32} & ... & r_{3m} \end{pmatrix} \quad (1)$$

Which, rij represents u_i degree of membership on v_j. (U, V, R) constitutes a fuzzy comprehensive evaluation model. Determine the importance of each factor index (also known as weights), the record is $A=(a_1, a_2, ..., a_n)$, meeting $\sum_{i=1}^{n} a_i = 1$, synthesized was

$$\overline{B} = A \bullet R = (\overline{b_1}, \overline{b_2}, ..., \overline{b_m}) \quad (2)$$

After normalization, get $B = (b_1, b_2, \ldots, b_m)$. So we can determine the object P judge rating.

Table 1. Definition of judgment scale.

Judgment Scale	Definition (For Last Level a_s, a_i Compares with a_j)
1	The former and the later are equally important
3	The former is a little more important relative to the later
5	The former is important relative to the later
7	The former is more important relative to the later
9	The former is absolutely important relative to the later
2, 4, 6, 8	Their importance between two adjacent judgments of the intermediate scale
Reciprocal	If the ratio of the importance of the element i and element j is a_{ij}, the ratio of the importance of the element i and element j is $a_{ji}=1/a_{ij}$

5.2. Determine the Degree of Confidence

In (U, V, R) model, the elements rij in R is determined by the Judges "scoring". For example, k judges, requires that each judge u_i makes a judgment comparison $(v_1, v_2, \ldots, v_m)$. Statistical scores and normalized to produce $(\frac{c_{i1}}{k}, \frac{c_{i2}}{k}, \ldots, \frac{c_{im}}{k})$, composition R0. $\frac{c_{ij}}{k}$ represents on both the "degree of membership" of u_i on v_j, but also reflects the judgment of u_i degree of concentration. Value of 1, indicating that u_i is credible. Value of zero is ignored. Therefore, the amount of reflection of this degree of concentration called "confidence." For determining the weight coefficient also exists a reliability problem.

After determining the various experts on indicators to assess the weight of the resulting analytic hierarchy process, the coefficient for the grading on the right, and thus determine the reliability of their results. When taking N levels, which corresponds to the quantized [0, l] on the interval N times equally. For example, N takes 4, then in turn get [0, 0.25], [0.25, and 0.5], [0.5, 0.75], [0.75, 1]. Indicators for j, k expert take over the right indicators to assess the resulting weight, obtain $(a_{1j}, a_{2j}, \ldots, a_{nj})$.

Fig. (**3**) is the result of the comparison between using the Fussy Evaluation and not. As can be seen from the figure, the indicators of using the Fussy Evaluation are all greater than the value of none using the Fussy Evaluation, in addition that two indicators are equal. Therefore, in the investment decision, the Fussy Evaluation can be well quantified targets for each function analysis to help make investment decisions.

The analytic hierarchy process and fuzzy comprehensive evaluation method has combined. Sub-goals and determine the index weight, using fuzzy comprehensive evaluation method for comprehensive evaluation of green public buildings by AHP. This method has the following advantages: Just to give a qualitative evaluation of staff each evaluation element description, and then through the analytic hierarchy process can be relatively accurately determine the weight of each element of the re-evaluation.; Not only takes into account the influence of various factors on the research questions, a comprehensive evaluation of the main multiple views, and effectively solve the fuzzy problems that appears in the evaluation process.

6. CONCLUSION

With the rapid development of the economy, accelerated urbanization, public buildings are in large numbers. How-

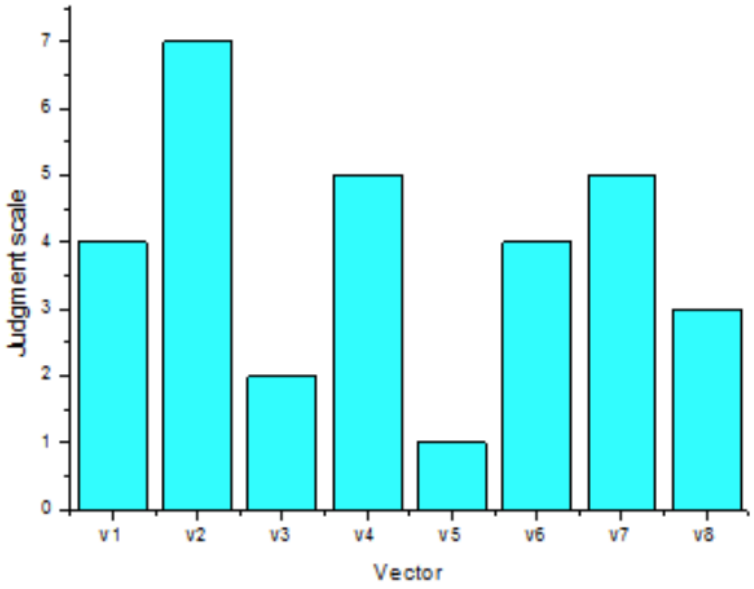

Fig. (1). Judgment scale example for each vector.

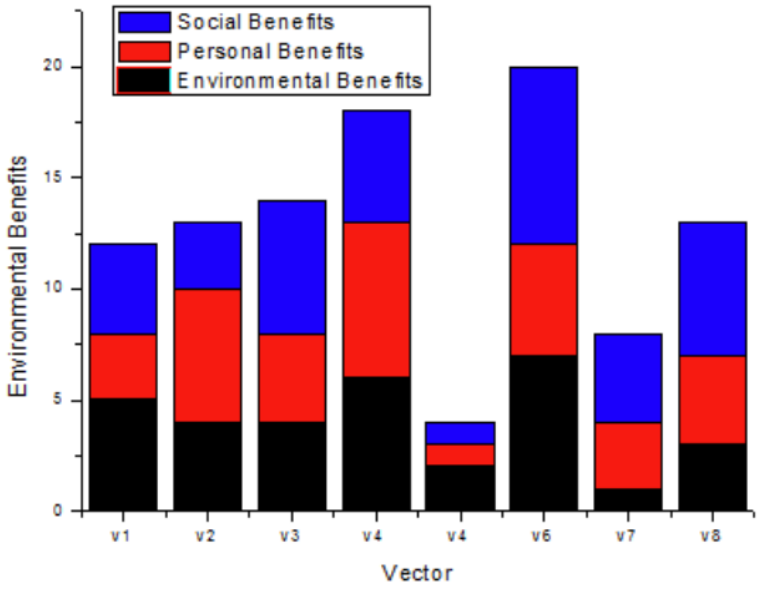

Fig. (2). Judgment scale of environmental benefits, personal benefits and social benefits.

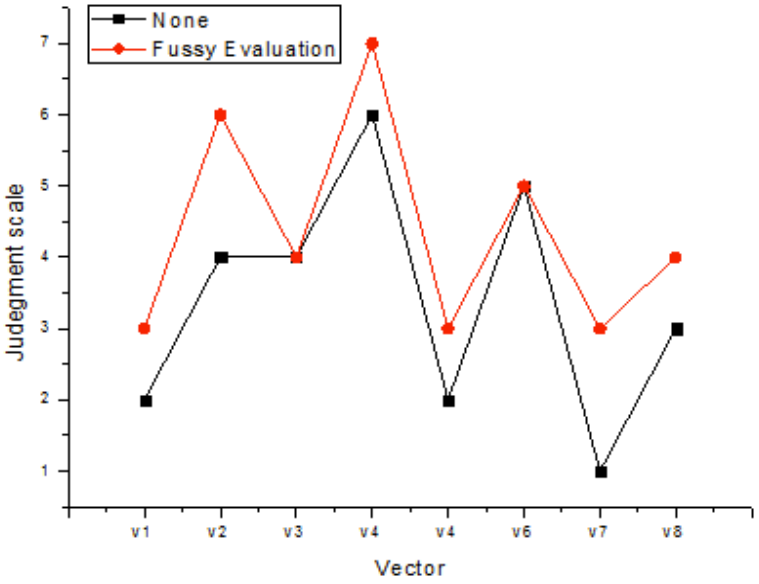

Fig. (3). The comparison results of using the fussy evaluation.

ever, in the development process of public buildings, there are the features that a large energy consumption, recycling rate, not strong structure and function. With the "green building" proposed, our government also began to introduce relevant policies and measures for green public buildings. Green public buildings are facing unprecedented opportunities. Appling the value engineering to public buildings green investment decisions can take into account environmental benefits, personal and social benefits of the three conflict parties, to achieve public green building requirements. This has profound implications for sustainable development of our economy and society, and building a resource about society and environment-friendly society.

In short, the method is easy to implement procedural law, intuitive, easy to operate, with a very good value, is a worthy comprehensive evaluation method of green public building.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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